DOCUMENT RESUME

ED 024 059 24 CG 002 341

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Information Processing and Concept Learning at Grades 6, 8, and 10 as a Function of Cognitive Style.

Wisconsin Univ., Madison. Research and Development Center for Cognitive Learning.

Spons Agency-Office of Education (DHEW), Washington, D.C. Bureau of Research.
Bureau No-BR-5-0216
Pub Date Mar 68
Contract-OEC-5-10-154
Note-51p.
EDRS Price MF-$0.25 HC-$2.65
Descriptors-*Adolescents, *Cognitive Processes, *Concept Formation, Grade 6, Grade 8, Grade 10, *Information Processing, Thought Processes, Verbal Ability
Identifiers-Concept Learning Problems, Hidden Figures Test, Tagatz Information Processing Test

This research furthers our understanding of the relationship between an organismic factor, "cognitive style," and performance on concept learning and information processing tasks. These results, obtained from students in grades six, eight, and 10, indicate that not only do "high analytical" type students perform better on this experimental task, but they also do better in certain school subjects. It was concluded that the Hidden Figures Test does measure level of field articulation in adolescents, and that significant differences between analytical and non-analytical subjects exist in intelligence, achievement, and information processing and concept learning abilities. (Author)

ED024059

BR-5-0216
PA-24

Technical Report No. 44

INFORMATION PROCESSING AND CONCEPT LEARNING AT GRADES 6, 8, AND 10 AS A FUNCTION OF COGNITIVE STYLE

By Wayne C. Fredrick

Report from the Project on Situational Variables and Efficiency of Concept Learning

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March 1968

The research reported herein was performed pursuant to a contract with the United States Office of Education, Department of Health, Education, and Welfare, under the provisions of the Cooperative Research Program.

Center No. C-03 / Contract OE 5-10-154

PREFACE

This technical report is based upon the dissertation of Wayne C. Fredrick. The examining committee consisted of Professors Herbert J. Klausmeier, Chairman; Gary A. Davis; Frank H. Farley; Thomas A. Romberg; and Willard R. Thurlow.

One major program of the Wisconsin R and D Center for Cognitive Learning is Program 1 which is concerned with fundamental conditions and processes of learning. This program consists of laboratory-type research projects, each independently concentrating on certain basic organismic or situational determinants of cognitive learning, but all united in the task of providing knowledge which can be effectively utilized in the construction of instructional systems for tomorrow's schools.

Of critical importance to the field of human learning is the area of concept learning, an area which enjoys vigorous experimentation most of which is designed primarily to reveal task or situational determinants of performance. Mr. Fredrick's research furthers (see Technical Report No. 32 by J. Kent Davis) our understanding of the relationship between an organismic factor, "cognitive style," and performance on concept learning and information processing tasks. These results, obtained from students in grades 6, 8, and 10, indicate that not only do "high analytical" type students perform better on this experimental task, but they also do better in certain school subjects.

Harold J. Fletcher
Director, Program 1

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ABSTRACT

The experimental literature suggests that the level of field articulation (LFA) reflects the ability to actively separate relevant from irrelevant information, an ability which is similar to information processing as it occurs in concept learning. The Hidden Figures Test (HFT) was used to measure the LFA of 256 boys and girls in Grades 6, 8, and 10. The Ss were also given a test of information processing (TIPT) and concept learning (CLP). Group testing was used, and Ss were paced on the items and were to answer every item.

The Hoyt reliability estimates of the HFT, TIPT, and CLP were .50, .69, and .65, respectively. In the HFT, some of the five options were easier to locate than others, while some options were chosen more often than chance. The items were difficult for the Ss, and a clear increase in analytical ability as a function of increasing grade level appeared. Sex differences on the HFT were not significant. The amounts of relevant and irrelevant information in an HFT item correlated with performance on the item. An examination of these correlations by groups showed that the sixth graders were more sensitive to these amounts of information than the older Ss, and that analytical Ss were sensitive to information levels while non-analytical Ss performed nearly randomly in regard to information levels.

The high HFT scorers tended to have higher IQ scores, higher grades, and performed better on the TIPT and CLP than the non-analytical Ss. An analysis of types of errors showed that high HFT scorers made fewer inclusion, exclusion, and indecision errors on the TIPT and CLP than the low HFT scorers. As grade increased, the correlation between HFT and TIPT also increased, which suggested that information processing ability becomes an increasing part of LFA.

It was concluded that the HFT does measure LFA in adolescents, and that significant differences between analytical and non-analytical Ss exist in intelligence, achievement, and information processing and concept learning abilities.

I
INTRODUCTION

The purpose of the present experiment was to test the conceptual ability of students at several age levels and determine the extent that these abilities were a function of cognitive style. The dimension of cognitive style measured was field articulation, which has been variously named global-analytical and field-dependence-independence. To some degree the dimension of equivalence range, or concept width, was also considered. The conceptual behavior measured was (a) the ability to process information about the attributes and values of positive and negative instances, and (b) the ability to categorize positive and negative instances of a concept.

Several factors determined the nature of the present study. The author had, in the past, been primarily concerned with the investigation of the effect of relevant and irrelevant information in concept identification (Fredrick, 1965, 1966). The investigation of relevant and irrelevant information showed that the difficulty or ease of identifying a concept was very dependent upon the absolute and relative amounts of each type of information. A study by Baggaley (1955) had shown that, of several mental factors, Strength of Closure was the most highly correlated with conceptual behavior. Strength of Closure was measured by the Concealed Figures Test (CFT), a test typical of the tests of field articulation. The implication was clear: concept identification and the CFT must each require a similar skill. When Lemke, Klausmeier, and Harris (1967) showed that concept identification and information processing were separate factors, the possibility arose that information processing was the skill common to concept learning and the CFT. Davis (1967) showed that a modern version of the CFT, the Hidden Figures Test (HFT), could be used to stratify Ss in concept learning experiments on the basis of cognitive style. With this as a background, the author designed and executed the present study.

Three tasks were used: (a) a test of cognitive style, the HFT, which measures the degree to which a S can articulate the field by requiring him to find geometric figures hidden in an organized context of straight-line patterns; (b) a test of information processing, the TIPT (Tagatz Information Processing Test), in which the S must decide on the basis of information available in two cards whether a third card is positive, negative, or indeterminate; and (c) a test of concept learning (CLP) consisting of two concepts which, if learned, enable the S to unambiguously categorize test items as "Yes" or "No."

The specific questions relevant to the study were as follows:

1. Are there differences in average HFT score for Grades 6, 8, and 10? For males and females?
2. Do individual items of the HFT vary in difficulty on the basis of (a) the amount of relevant information, (b) the amount of irrelevant information, (c) the ratio of a to b, or (d) some other quantity?
3. Are high HFT scorers influenced by a, b, and c, above, differently than low HFT scorers. Are males influenced differently than females? Are the various grade levels differently influenced?
4. Does performance on the TIPT vary as a function of HFT score? Does it on the CLP?
5. How does the HFT relate to IQ and GPA? How do the TIPT and CLP relate to IQ and GPA?
6. Which subject—English, social studies, or mathematics—correlates highest with HFT, TIPT, and CLP performance?
7. Do high and low HFT scorers show different characteristics in (a) the number of inclusion errors, exclusion errors, and errors of indecision on the TIPT and CLP; (b) reasoning from positive and negative instances on the TIPT; and (c) concept learning at low and high levels of irrelevant information? Do males differ from females on a, b, and c? Do sixth, eighth and tenth graders differ on a, b, and c?
8. Are there grade and sex differences in overall performance on the TIPT? On the CLP?
9. Psychometrically, how adequate are the HFT, TIPT, and CLP?

II
RELATED LITERATURE

Reviews of many of the issues in the domain of cognitive style can be found in Witkin, Lewis, Hertzman, Machover, Meissner, and Wapner (1954), Gardner, Holzman, Klein, Linton, and Spence (1959), Messick (1961), Messick and Ross (1962), Witkin, Dyk, Faterson, Goodenough, and Karp (1962), Christie and Lindauer (1963), Scheerer (1964), Holtzman (1965), and Tyler (1965).

Concept formation has received thoughtful attention in reviews by Vinacke (1951) and Kendler (1961). A thorough bibliography of the experimental work in concept learning has been compiled (Klausmeier, Davis, Ramsay, Fredrick, & Davies, 1965), and several books on the subject are available (Bruner, Goodnow, & Austin, 1956; Hunt, 1962; Bourne, 1966; Klausmeier & Harris, 1966).

THE DEVELOPMENT AND THEORY OF THE HIDDEN FIGURES TEST

Tests in which a person is required to find a figure which is embedded in a context have developed from Gottschaldt's (1926) study of embedding (Witkin, 1950). Witkin used 8 figures and 24 patterns that had been developed by Gottschaldt and added color to make the task of finding the hidden figure more difficult. The Witkin task was an individual test in which Ss were first shown a complex pattern, then the figure to be found in the pattern, and finally the pattern again. In this manner, the Ss never saw the figure and pattern simultaneously, so that the task involved a substantial memory factor. Witkin allowed up to 5 minutes for each pattern, the time-to-solution being the dependent measure. Witkin (1950) showed that this test, the Embedded Figures Test (EFT), produced striking interindividual differences and intraindividual consistencies. The range in time was from a low of 2 minutes for some Ss to a high of 71 minutes. The correlations between items were very high, indicating that the ability to find the figures was a persistent characteristic of an individual. Male Ss were better able to find the embedded figures than the female Ss, and the difficulty level of individual items varied considerably. Witkin concluded that the process which the EFT was measuring was the adherence that Ss showed to the obscuring pattern. He further pointed out that those Ss adhering closely to the pattern would probably assume a perceptual rather than a conceptual strategy in tests of concept learning (Vygotsky blocks) and intelligence (Kohs block design). These Ss he called field dependent.

Witkin in 1965 defined the field-dependent mode of perceiving as being

> ... strongly dominated by the overall organization of the field, and parts of the field are experienced as "fused." In a field-independent mode of perceiving, parts of the field are experienced as discrete from organized background. There is now considerable evidence that a tendency toward one or the other ways of perceiving is a consistent, pervasive characteristic of an individual's perception [1965a, p. 318].

The tests Witkin has used to measure the field-dependence-independence dimension include the BAT (Body Adjustment Test), the RFT (Rod and Frame Test) and the EFT, all of which have in common the task of keeping an object separate from an organized field in perception (Young, 1959). People who are at the extremes of this dimension have been labeled "global" and "articulated" by Witkin. The global Ss are those whose organization of the field as a whole determines how the parts are experienced, while the articulated Ss experience the parts as discrete and the whole as structured.

Witkin (1964) cited a study (Karp, 1962) which shows that field articulation requires more than figure-ground separation. Articulation requires the ability to overcome an organized embedding context; a random context achieves little more than a momentary distraction from the figure (Karp, 1963). The results of a study by Gardner and Long (1962), however, seemed to show that "the degree of field-articulation is a general characteristic of the individual's cognitive behavior requiring no special assumptions about the organizational properties of the field [p. 387]." The irrelevant stimuli need only be quite compelling. Selective attention to the relevant parts of the complex figures may be the key to successful response (Gardner & Long, 1961). In an extensive factor analytic study of the EFT, Messick and Fritzky (1963) found scores on the EFT correlated highly with Element Articulation and Background Articulation.

The stability of measurement of tests such as the EFT has been shown repeatedly by high test-retest correlations for both adolescent and adult groups (Witkin, 1965a; Dana & Goocher, 1959). Various attempts to manipulate cognitive style experimentally have been unsuccessful (Witkin, 1965a; Elliott & McMichael, 1963).

A short form of the EFT has been developed which seems as reliable as the earlier, longer version developed by Witkin (Jackson, 1956). In the short form only 12 items are used and the time is reduced to 3 minutes per item.

Jackson, Messick, and Myers (1964) have developed other group and individual versions of the EFT. Some of these use colors, as Witkin did, and others do not. For some of these forms the memory requirements of the task have been eliminated by printing the figure to be found on the same page as the patterns, thus making it a multiple choice test. Analysis of these various forms has shown that the trait of field articulation is robust and is measured successfully by each of the forms (Jackson et al., 1964).

The Hidden Figures Test (HFT) is one of the test forms that has come from the Jackson et al. research. The HFT is a multiple choice group test that does not use color or involve memory. It is easy to administer and has been used successfully by other researchers (Davis, 1967). The HFT is cited by French, Ekstrom, and Price (1963) as a reference test for studies in cognitive style.

The underlying dimension of the HFT and other such tests is field articulation, and it is evident in several tasks including the BAT, RFT, EFT, illusions, size constancies, reversible perspectives, and in Einstellung problems (Witkin, 1964). It appears that the ability to find relevant material embedded in a large amount of irrelevant material also generalizes to tactile and auditory embedded figures tests (White, 1954).

Faterson (1962), summarizing the work on field articulateness said,

> Thus individual consistency in functioning extends from body orientation tests to tests which require the overcoming of an embedding context but do not involve body position, to parts of conventional intelligence tests which require an analytical approach, to insight problems which require restructuring, to clarity of experience in unstructured situations like the Rorschach and the interview, to articulateness of the body concept, and to various manifestations of a sense of separate identity. We have used the term "articulateness of experience" as descriptive of the dimension that underlies functioning in this variety of situations. According to this formulation, the field-dependence-independence dimension may be thought of as a manifestation, in specifically perceptual situations, of a more general style of experiencing [Faterson, 1962, pp. 180–181].

COGNITIVE STYLE AS A FUNCTION OF SEX, AGE, AND IQ

Sex Differences

Witkin (1950) in a study in which 102 college students were tested on the EFT found significant differences between males and females in the time needed to find the figures in the patterns. Men needed an average total time of approximately 16 minutes to complete the 24 items, while females needed about 23 minutes and were slightly more variable than males. Elkind, Koegler, and Go (1963) found the mean time per EFT item to be 20.25 seconds for males, and 52.60 seconds for females. In a study by Bieri, Bradburn, and Galinsky (1958), female college Ss were significantly poorer on a short form of the EFT than males ($p < .01$). Bieri et al. reasoned that the difference between the sexes was due to the higher mathematical aptitude of the males and their conceptual approach to stimuli. Schwartz and Karp (1967) found males to be less field dependent between the ages of 17 and 39 than females, but no differences in dependency existed between groups of older men and women.

On the other hand, Evans (1967), using a shortened version of the EFT (eight items) with 59 undergraduates, reported no sex differences. Nor did Stuart, Breslow, Brechner, Ilyus, and Wolpoff (1965) report any sex differences on the EFT. Bieri (1960), in a repeat of the Bieri et al. (1958) study using the same procedures and other college Ss, found no differences between males and females. Vaught (1965) suggested that Ss with similar RFT scores behave in a similar way independent of sex.

The CHEF, a children's version of the EFT, shows no sex differences (Goodenough & Eagle, 1963). No sex differences were reported in two studies that used the HFT (Jackson, Messick, & Myers, 1964; Willoughby, 1967).

A possible cause of the sometimes obtained sex differences is the cultural stereotype that society gives to young males and females. The expectation that men be independent and women dependent does seem to produce the expected behaviors (Christie & Lindauer, 1963).

Age Differences

The development of cognitive style has been shown by Witkin et al. (1954), by Kagan, Moss, and Sigel (1963), and by Piaget (Flavell, 1963) to progress from a relatively global approach to a more analytical approach. This development has been studied from the age of 8 through adulthood with the stability of scores showing that a person's cognitive style is largely determined by the age of 8. Goodenough and Eagle (1963) showed that the ability to overcome an embedding context clearly increases from ages 5 to 8 for both sexes ($p < .001$). Schwartz and Karp (1967) showed that field dependence increased from ages 17 to 30 and from 39 to 58. This increase in field dependence continued from ages 60 to 90, although more so for retired persons than for their employed peers (Karp, 1967).

As yet there has been no evidence for Piagetian stages in the development of cognitive style. The transition from global to analytical seems to be stable, gradual, and continuous, with students retaining their positions relative to other students.

In discussing Piaget's views on the development of perception, Flavell concluded,

> In a rough way, one could characterize Piaget's general scheme of development as one in which the growing subject plays a progressively more active and assertive role in his commerce with the environment. In the perceptual area, this principle gets expressed as a gradual increase with age in behavior of the perceptual activity type, with consequent diminution in the force of the primary field effects [Flavell, 1963; p. 235].

Perceptual activity is defined by Piaget as a broad range of behaviors which have the function of exploring and comparing stimuli to overcome the primary perception effects. Primary perception, or primary field effects, are those that result from passive momentary fixations upon stimuli. Development of perception does not involve a sequence through distinct qualitative stages, but rather a simple decline of perceptual passivity with a corresponding gain in active perceptual analysis (Flavell, 1963).

Concept learning, however, does seem to have some identifiable stages (Flavell, 1963). In a study by Sigel (1953) 7-, 9-, and 11-year-old children were to put objects into groups of their own choosing. Sigel then asked their reasons for the groups they arrived at. These reasons were rated as perceptual or conceptual. The 7-year-olds used mostly the thematic perceptual groupings, 9-year-olds used perceptual and conceptual equally, and the older children used primarily the conceptual grouping. Kagan has discussed the apparent stages in the development of conceptual hierarchies in some detail (Klausmeier & Harris, 1966).

Intelligence Differences

The relationship between IQ and field articulation is complex. Significant correlations usually exist between intelligence scores and tests of the global-articulated dimension (Jackson, Messick, & Myers, 1964). Analysis of the factor analytic relations between the WISC and the perceptual tasks showed that only the Block Design, Picture Completion, and Object Assembly subtests were significantly related to field articulation as measured by the BAT, RFT, and EFT. The verbal subtests of the WISC were not related to level of field articulation (Goodenough & Karp, 1961; Karp, 1963). The three WISC subtests that were related require the S to separate item from context, an ability which the cognitive style tests are also measuring.

Bieri, Bradburn, and Galinsky (1958) found significant correlations of $-.50$ and $-.40$ ($p < .01$) between time scores on the EFT and the mathematics subtest of the Scholastic Aptitude Tests for females and males, respectively. The correlations between the EFT and the verbal subtest were not significant.

White (1954) found a correlation of .59 between Concealed Figures Test scores and performance on the California Test of Mental Maturity for 15-year-old boys and girls. Jackson (1957) found a correlation of $-.53$ between time scores on the EFT and intelligence scores.

Performance on tests of field articulation is related to intelligence, and probably the relationship exists because of certain mathematical or perceptual subtests of IQ tests and not because of the verbal subtests. This lack of relationship between verbal subtests and field articulation makes the issue of cognitive style affecting conceptual behavior more tenuous.

Concept learning usually correlates highest with verbal and reading subtests of intelligence tests (Ladd, 1967; Lemke, Klausmeier, & Harris, 1967).

CONCEPTUAL BEHAVIOR AND COGNITIVE STYLE

Baggaley (1955) tried to identify some of the psychological processes involved in concept formation. He used nine of Thurstone's factors, each of which represented a cognitive variable, and obtained the correlation between the scores on the cognitive variable and the performance on a card sorting task. In the sorting task a set of 32 cards that contained five bi-valued dimensions was used. The dimensions were the word red or black typed in capital or lower case letters in red or black ink either once or twice with or without a rectangular border. The correct sorting rule which the Ss had to obtain was that "the 8 cards which said black and were enclosed in a rectangular border belonged to the right-hand section of the box [Baggaley, 1955, p. 299]."

Of the nine cognitive variables, five were significantly correlated with the dependent measure of time and errors on the sorting task. These five factors and their correlations with the dependent measure, called "level score" by Baggaley, were Strength of Closure .45; Deductive Reasoning .31; Inductive Reasoning .26; Speed of Closure .28; and Analogical Reasoning .36. The Analogical Reasoning factor was used by Baggaley to obtain suitable weights for time and error scores that, when combined, would give the highest multiple correlation with the scores on the test of Analogical Reasoning.

Baggaley noted that the fact that Strength of Closure had correlated most highly with the card sorting performance was of great psychological interest and pointed to "concentration on one aspect of a complex stimulus situation [p. 304]" as the process common to the closure and card sorting tasks. Strength of Closure and Numerical Reasoning were the only factors that correlated significantly with "variability score," a dependent measure that Baggaley felt was indirectly a measure of analytical ability on the card sorting task.

From the results of his correlational study, Baggaley concluded that persons high on Strength of Closure employed an analytical method in the card sorting task. The Strength of Closure factor was measured by Thurstone's Concealed Figures Test (CFT), a group paper-and-pencil test that was the prototype for the Hidden Figures Test and the Embedded Figures Test. Persons high on Speed of Closure were not analytical in the card sorting task, but rather tended to use a wholistic approach to concept formation.

The importance of the Baggaley study for the present paper is due to the finding that the performance on the CFT correlated more highly with a conceptual task than did any other cognitive variable, including cognitive variables directly related to intelligence, namely inductive and deductive reasoning, verbal meaning, and word and ideational fluency. There are, however, some methodological problems which detract from the clarity of Baggaley's results. One problem exists in the calculation of the dependent variable, level score. This variable was weighted to correlate as high as possible with the test of the factor Analogical Reasoning. This test was the Figure Analogies Test. The Figure Analogies Test requires "concentration on one aspect of a complex stimulus situation" just as the CFT does. It might be expected that these two tests, both of which use figures, would correlate high and positive. Thus, the high correlation of the Strength of Closure factor with sorting performance could have been due largely to the correlation between the Figure Analogies Test and the CFT.

A second problem is the result of the particular dimensions and concept that Baggaley selected to study. His use of red and black written on cards in red or black ink is analogous to the Stroop Color-Word Test in which names of colors are written in various colors of ink, and the S responds to either the colors, or the words, or both. Good performance on the Color-Word Test correlates positively with good performance on tests similar to CFT (Gardner et al., 1959; Messick & Fritzky, 1963). It may be that the Strength of Closure factor correlated significantly with conceptual behavior largely because of the color-word effect rather than because of processes required in concept learning.

The closure factors had previously been analyzed by Botzum (1951) and Pemberton (1952). Botzum found that Induction, Deduction, and Flexibility of Closure were first-order factors that formed a second-order factor which was interpreted as an analytic factor. Pemberton's results were similar to those of the Botzum study. Again Flexibility of Closure combined with reasoning factors to form a second-order analytic factor. Three reasoning tests had their highest loadings on the Flexibility of Closure factor, and these high loadings indicated to Pemberton that the closure factor generalizes in the cognitive domain and is associated with analytical ability. In both the Botzum and Pemberton studies, Speed of Closure was associated with a second-order factor called Speed of Perception that was different from the analytic factor. Thus, the results of these two studies agree fully with the correlations obtained by Baggaley (1955).

More recently, Gardner, Jackson, and Messick (1960) have found tests of field dependence and Flexibility of Closure to define a single factor. Their research has led them to conclude that "articulation of experience by means of selective attention to relevant versus compelling irrelevant stimuli may be the key to effective performance ... [p. 121]" on the EFT and tests of Strength of Closure.

Gardner called the field-dependent Ss those who were "unable to extract the relevant item from the surrounding field [Gardner, 1962, p. 193]." This statement calls attention to the items in the EFT and HFT as displays of relevant and irrelevant information and leads to the possibility of analyzing items in terms of the amounts of each kind of information, as was done in the present study.

Gardner et al. (1959) discussed the fact that some items in the EFT were perceptually easy (i.e. they were "seen" immediately) while others were so difficult that the S had to "figure out" the location of the simple figure in the pattern. The variability led Gardner et al. (1959) to do an item analysis of the EFT. The item analysis showed two major clusters, a group of items that were readily perceived and another group that had to be "figured out." Factor analysis revealed that for females both groups of items had large loadings on the largest of the extracted factors, Field Articulation. Perceptual analysis, thus, was an important determiner of time scores in both item clusters. The field-articulation factor also had high loadings on the RFT, the Color-Word Interference Test, and tests of size estimation. For men, the more difficult cluster of items and the RFT score loaded moderately and in opposite directions on a scanning factor. The field-articulation factor seemed to appear for the male Ss as two factors, neither of which were interpreted because of missing data from 8 of the 30 males.

Jones (1967), in a factor analysis of concept formation, found that the more accurate concept learners were also very able in tests that required multiple visual discriminations, a skill probably very much a part of the field-articulation factor.

Elkind, Koegler, and Go (1963) gave 56 Ss the short form of the EFT along with the Abstraction Test (SHA) and the Vocabulary Test (SHV) of the Shipley Hartford Scale. Elkind et al. reasoned that the SHA qualified as a test of perceptual concept formation since the Ss must abstract relations from the arrangement of letters and numerals. The males and females were divided into groups of high and low EFT scorers. The high scorers performed significantly better on the SHA than the low scorers, but there were no differences on the SHV. The conclusion was that field independence "is an asset on tests that require the abstraction of elements and things as opposed to words [p. 385]."

Lee, Kagan, and Rabson (1963) showed that a preference for pairing objects on an analytical basis, rather than on the basis of inference or relation, determined the type of concept that third-grade boys could most easily learn. The analytic boys attained analytic concepts more quickly than they attained inferential or relational concepts. Non-analytic boys learned the relational concepts most readily.

Ohnmacht (1966) divided Ss into two groups on the basis of their scores on the group version of the EFT. The field-independent Ss were more successful than field-dependent Ss in dealing with reversal and/or nonreversal shifts. However, Ohnmacht reported no significant differences between the upper and lower groups of EFT scorers in learning the original concept. An attempt was made to reanalyze the Ohnmacht data without using the $\sqrt{x + 15}$ transformation that he used and which seemed unjustified. Several errors were found in the reported data which made reanalysis useless. It is sufficient to say that the mean numbers of trials to criterion on the first concept were 29.45 and 39.65 for the field-independent and field-dependent Ss, respectively, a substantial difference in conceptual ability that is probably statistically significant.

Davis (1967) tested twelfth-grade boys on the HFT. He then selected from the group of 310 Ss 30 high HFT scorers, 30 medium scorers, and 30 low scorers. These 90 Ss were given a concept identification task. The instances of the concept were made up of bi-valued figural dimensions. One, three, or five dimensions were irrelevant while two were always relevant. The high HFT scorers made significantly fewer errors than the medium scorers who in turn made fewer errors than the low scorers ($p < .01$). The HFT score did not interact with problem complexity as might be expected.

In a second experiment, Davis (1967) selected other groups of low and high HFT scorers and tried to train them to be analytical in the concept identification task. Training consisted of the Ss being required to state the values of all the dimensions of an instance. Another training procedure gave the Ss prompts so that they could analyze at their leisure why an instance was or wasn't part of the concept. Again the high HFT scorers made fewer errors than the low scorers ($p < .05$), but the two groups were not differentially affected by either training procedure.

Gardner and Schoen (1962) offered a second dimension of cognitive style that is critical in concept formation. In addition to field dependence, they claimed, equivalence range is a principle of cognitive control which has direct implications for concept learning. Their factor analytic studies showed that equivalence range (conceptual differentiation) was a factor common to several sorting tasks.

Gardner and Long (1960) have shown that the Object Sorting Test which measures equivalence range and the Color-Word Test which measures constricted-flexible control are stable over time. Forehand (1962) found, however, that equivalence range generalized to a limited range of behaviors that were basically perceptual. Sloane, Gorlow, and Jackson (1963) found that the sorting tasks used by Gardner and his associates resulted in six factors rather than a unitary factor which could be called equivalence range. The largest factor in the analysis, though, was an equivalence range factor that was consistent across content areas. Moran, McGaughran, and Leventhal (1957) showed that equivalence range was consistent across three types of tasks; object sorting, similarities and synonyms, and could be called a "conceptual trait."

INFORMATION PROCESSING AND CONCEPT LEARNING

The relationship between information processing and concept learning has been discussed at length by Hunt (1962). Two experimental studies are directly relevant to the present research since the same information processing task was used. In the first study (Tagatz, Lemke, & Meinke, 1966) the TIPT and concept identification tasks were given to seventh-, eighth-, and ninth-grade pupils. On the TIPT a significant improvement with age was noted ($p < .01$) but no differences were found between the performance of males and females. The items in which a YES card provided the information (See TIPT in Appendix A) were not different from the items in which a NO card provided the information. The items in which "Can't Tell" was the proper response were significantly more difficult than the "Yes" items ($p < .01$). The "No" items were intermediate in difficulty. The Ss also showed improved performance with age on the conceptual tasks. Tagatz et al. reported that KR-21 reliability of the YES items in Part I was .65, and the NO items, .40.

When "Yes," "No," and "Can't Tell" items in Part I were considered separately the KR-21 reliabilities were .65, .42, and .60, respectively. These reliabilities are directly relevant since Part I of the TIPT was used in the present experiment. Factor analysis of the TIPT and the concept tasks and a battery of achievement tests revealed a general achievement factor, an information processing factor, and two concept learning factors. The information processing factor correlated .65 with the general achievement factor and .54 with one of the concept learning factors. A second factor analysis using the response types ("Yes," "No," and "Can't Tell") again revealed the achievement factor and two other factors, one of which was an information processing factor that loaded negatively on "No," items and positively on "Can't Tell" items. The second factor loaded highly on all three item types and arithmetic reasoning. These two factors suggested to Tagatz et al. that there were two distinct, characteristic ways of processing information.

> A person of the first typology has a tendency to specify all cards which are not exemplars as being nonexemplars. He would get disproportionately high scores on items with "No" answers and low scores on items with "Can't Tell" answers, hence the bi-polarity .... On the other hand people who use the analytic approach would have a tendency to do equally well on all three information processing items according to response options [Tagatz et al., 1966, p. 76].

The first factor did not correlate with the achievement factor, but the second, which Tagatz et al. termed "analytic," correlated .73 with the achievement factor. Further factor analyses using the incomplete image solution showed that reasoning from YES items formed a factor and reasoning from NO items formed a factor, and that concept learning was a factor separate from these two factors. The concept learning factor correlated with the YES item factor ($r = .62$) but not with the NO item factor ($r = .12$). A second image analysis using the item response types showed no concept learning factor but did show that "Yes," "No," and "Can't Tell" items each delineated a separate factor. Of these three item response factors only the "Yes" factor correlated highly with the achievement factor ($r = .78$).

In the second study (Lemke, Klausmeier, & Harris, 1967) 16 tests of cognitive abilities and 18 measures of information processing (TIPT) and concept attainment were given to 94 female college students. These 34 measures were intercorrelated and factored. The Alpha Factor analysis yielded 7 of the 8 cognitive ability factors that the tests were supposed to measure. Two information processing factors were found (Inclusion-exclusion and Indeterminate), and 3 concept attainment factors.

The correlations of the obtained factors were generally low. One result that was pointed to by Lemke et al. was that General Reasoning, Induction, and, to a lesser extent, Verbal Comprehension correlated consistently with the concept attainment and information processing factors, while Rote Memory, Span Memory, Spatial Scanning, and Deduction did not correlate with these factors. Also noted was the fact that both information processing and concept learning were not unitary factors and were not closely related to each other.

IMPLICATIONS FOR EDUCATION

Witkin (1965b) has discussed the implications of the articulateness dimension in regard to personality, pathology, and therapy. The implications for education may be seen in the construct of educational set. Siegal and Siegal (1965) tried to determine the specific kind of context a learner tends to extrapolate from his educational experiences. They found that educational set was a continuum, with a predisposition to learn factual content at one end and a predisposition for conceptual content at the other. The conceptually oriented students learned both more concepts and more facts than the factually oriented students. The construct of field articulation also seems to be a predisposition toward one or another interpretation of educational experiences. The evidence which shows that a person's conceptual behavior is partially a function of cognitive style has been demonstrated repeatedly. Ladd (1967) has pointed to the ability to adopt different interpretations of data as a skill required in concept learning. Lack of this ability shows itself in errors due to the S's slow adaption to the concept learning task. A global approach may not affect conceptual ability per se, but it may be indicative of a weak, passive, and inappropriate approach to concepts, an approach that must be overcome before learning can occur at the level of analysis that concepts require.

Analytical ability has further implications for problem solving and the apparent functional relationship between articulation and the Einstellung, the development of mental sets. Guetzkow (1951) viewed problem-solving ability as being determined by three factors. He called these factors fluency of ideas, reasoning ability, and set. Fluency and reasoning are two factors which are positive variables in a problem-solving situation. Set is a negative process, operating to oppose solution and causing perseveration in a given mode of attack. Guetzkow found two set-related aspects of behavior in the Luchins water-jar problems and the Maier two-string problem. One aspect was susceptibility to set, and the other was the ability to surmount set. The Ss who were more susceptible to set showed significantly poorer performance on the Gottschaldt Figures Test than did the non-susceptible Ss ($p < .05$). Guetzkow described these susceptible, global Ss as "unable to shift from one standard to a subsequent one .... a lag in going from sub-task to sub-task [Guetzkow, 1951, p. 238]." When he compared the Ss who were able to surmount set to those not so able, he found that on both the Gottschaldt task and on a Hidden Pictures Test those who overcame set in the Maier and Luchins problems scored significantly higher ($p < .01$). Forehand (1962) has also suggested that the ability to shift sets accounts for the relationships among the cognitive style dimensions.

III

METHODOLOGY

Ss AND SCHOOLS

The Ss used were 128 boys and 128 girls from three Wisconsin schools. The 256 Ss were 88 sixth graders (46 females, 42 males) from an elementary school in a small city (pop. about 50,000), 82 eighth graders (45 females, 37 males) from a junior high school, and 86 tenth graders (37 females, 49 males) from a senior high school in a larger city (pop. about 100,000). Each of the schools are large public schools with typical heterogeneous student bodies. Both cities are industrial with large numbers of middle class working families.

IQ and GPA

IQ scores and grades in English, social studies, and mathematics were obtained for most of the Ss. For seven Ss (three sixth graders, two eighth, and two tenth) IQ scores were not available, so their scores were estimated by their teachers in the sixth and eighth grades, and set at 105 in the tenth grade. The Otis IQ Test was used at both the junior and senior high schools. At the senior high school the Otis had been given to all tenth graders in the fall of 1966. At the junior high school the Otis had been given in the fall of 1965 when the Ss were seventh graders. The elementary school used the Lorge-Thorndike which had been given to all sixth graders in the fall of 1966. The average IQ scores of the Ss from the elementary, junior high, and senior high schools were 107.4, 107.9, and 108.7, respectively. The small and insignificant differences in IQ scores suggests that the three schools were satisfactory in providing groups of intellectually equivalent Ss at three grade levels.

The grade point averages (GPA) in three courses were obtained from the teachers or from the students themselves. In each school the grade requested was the third quarter cumulative report card grade. At the junior high school the teachers provided this grade, while at the other two schools the students provided it. The courses for which grades were requested were English, social studies, and mathematics. In the case of sixth graders the courses corresponding to those requested were reading, history, and arithmetic, respectively. For eighth graders the corresponding courses were English, history, and mathematics; for tenth graders they were as requested. The grades were converted to their numerical equivalents (i.e., A = 4, B = 3, C = 2, D = 1, and F = 0). Three sixth graders did not report any grades. One eighth grader had recently moved into the school and his grades were not available. One tenth grader reported no social studies grade, and nine tenth graders were not taking a mathematics course. The number 2 was assigned as the grade in all of these omissions. For a total GPA score, the numerical value of the sum of the English, social studies, and mathematics grade was used.

Omitted Ss

In all, 262 Ss were tested as part of the experiment, but the data from one sixth grader and five tenth graders were omitted. The sixth grade boy and a tenth grade girl did Part II of the Hidden Figures Test instead of Part I. Two tenth-grade boys did not answer any of the items on the information processing test, and two tenth-grade boys had school duties which prevented their finishing the test. These six omitted Ss were not considered in any of the analyses, but every response of the remaining 256 Ss was used.

MATERIALS

The materials required for the experiment were Part I of the Hidden Figures Test (HFT), developed by Educational Testing Service in 1962; Part I of the Tagatz Information Processing Test (TIPT), developed in 1966 by Glenn E. Tagatz of the Wisconsin R & D Center; and the two concept learning problems (CLP), designed by the present author. The tests are shown in Appendix A. A stopwatch was used by the author to pace each of the items in the three tests and to time instructions, examples, and rest periods. The tests were given in the schools in rooms that had very adequate seating capacity and lighting.

TEST PROCEDURE

HFT

An item in the HFT consisted of patterns of lines in which one of five figures was embedded. The task of the S in this test was to mark the letter (A, B, C, D, or E) of the figure hidden in the pattern. Normally, the 16 items of Part I of the test are given with a 10 minute time limit without being paced, and Ss are told not to engage in wild guessing. So that item analysis procedures would be meaningful, the directions to the Ss were changed somewhat. The Ss were told to answer every item, and that they would be paced. The pacing was implemented by the author saying to the Ss, "Go to problem number ___" after intervals of 45 seconds. For the 16 items in Part I; A, B, C, D, and E were the correct responses 3, 3, 3, 3, and 4 times, respectively.

TIPT

The TIPT consisted of 30 items. In each item there was a FOCUS CARD made up of six dimensions (see instructions for the TIPT in Appendix A), and two other cards also made up of these six dimensions. Of these latter two cards, one was marked either YES or NO, and the other was marked with a question mark. The task of the S was to decide whether the card marked " ?" was a "Yes" card, a "No" card, or whether he hadn't sufficient information to decide (i.e., "Can't Tell"). Presumably the Ss makes the decision of "Yes," "No," or "Can't Tell" by processing the information given to him by the FOCUS CARD and the second YES or NO card. As in the HFT, the Ss were told to answer every item, and they were paced at the rate of 20 seconds per item.

The TIPT was constructed so that 15 items required the S to reason from a YES card, and the 15 other items, from a NO card. Ten of the 15 YES card items were "Yes," and ten of the 15 NO card items were "No." The remaining ten items were "Can't Tell." This construction allowed several dependent measures to be obtained.

CLP

The CLP consisted of two stories from which the Ss could learn (#1) which plants would be good to eat, and (#2) which animals would bite. As in the TIPT, the plants and animals were made up of bi-valued dimensions. The plants consisted of four dimensions, of which two were relevant to defining the set of plants good to eat. The animals consisted of seven dimensions, of which two were relevant for defining the set of animals that would bite. The plant concept was considered the low irrelevant information problem, and the animal concept was the high irrelevant information problem. The task of the Ss was to categorize new instances of the plants and animals. The Ss were paced at the rate of 15 seconds per each of the 24 items (12 items in #1, 12 in #2), and they were told to answer all items. The dependent measures provided by the CLP included instances correctly categorized and inclusion and exclusion errors.

Sequence of Events

The actual test procedure was kept the same for the three grade levels. The test session began with the principal or supervisor of the children introducing the author and his assistant as guests and asking that the children cooperate. The school related people then left the room, leaving the children in the hands of the author and his assistant. The author gave some introductory remarks in which the following points were made:

1. You are going to try out some new tests.
2. These tests will not affect your school grade.
3. We want you to do your best, do your own work.
4. All of your answers will be made in these booklets.
5. You are to answer every problem.
6. There is only one right answer for each problem.
7. Each test will be paced, we will tell you when to go from one problem to the next.
8. Do not begin the tests until we tell you.

At this time the test booklets were handed out to all the Ss of a particular grade. The Ss were requested to write their name at the top of the HFT and their name and sex on the first page of the TIPT-CLP booklet. The Ss were asked to give their most recent report card grade for English, social studies, and mathematics.

The attention of the Ss was directed to the instructions for the HFT. The author read the instructions aloud to the Ss. Care was taken to allow $1\frac{1}{2}$ minutes for the two examples. The following instructions were repeated, "There is only one of these figures in each pattern, and this figure will always be right side up and exactly the same size as one of the five lettered figures." The author then said, "Remember to answer every item, and to go from item to item when I tell you. Turn the page and begin number one." After 45 seconds had elapsed, he said, "Go to number two." Every 45 seconds the Ss would be instructed to move to the next problem until 12 minutes had elapsed and all 16 items were completed. After the HFT the Ss rested for 1 minute.

After the short rest period the instructions for the TIPT were read aloud by the author. Care was taken to allow at least 20 seconds thinking time for each of the four examples. The Ss were reminded to answer every item and move from item to item when so instructed. The Ss completed the 30 items of the test in 10 minutes since they were paced at the rate of 20 seconds per item in the same manner as in the HFT. Another 1-minute rest period followed the TIPT.

The instructions for the first CLP problem were then read aloud by the author. The Ss were allowed 2 minutes to look at the six examples of YES and NO plants. They were then told to turn the page and not look back at the examples and to begin item number one. The 12 items took 3 minutes, being paced at 15 seconds per item. The second CLP was immediately begun following the last item in CLP #1. Again 2 minutes were allowed for studying the six examples, and the 12 test items were paced at 15 seconds per item. The test booklets were then collected, and the Ss were thanked and dismissed.

No problems were encountered in any of the three test sessions. Each session went extremely well for the number of students involved. Interest of the students seemed to be very high, especially in the sixth and eighth grades.

Time and Date

The distribution of time spent on each of the tests was approximately 16 minutes for the HFT (12 minutes plus instructions), 17 minutes for the TIPT (10 minutes plus instructions), and 12 minutes for the CLP (6 minutes plus instructions) for a total of 45 minutes, excluding rest periods and preliminary remarks. The total time in each case was about 50 minutes, which fit well into the schools' schedules.

The tests were given at the junior high school from 10:00 to 11:00 A.M. on Friday, May 12, 1967; at the senior high school from 1:30 to 2:30 P.M. on Friday, May 12, 1967; and at the elementary school from 10:00 to 11:00 A.M. on Friday, May 19, 1967. The tests were given to large groups, with the author in charge of each of the three testing sessions, and in each session the same assistant, Mrs. Jan Rabidou.

DESIGN AND ANALYSES

The test situation was designed to give various dependent measures of abilities in information processing and concept learning as a function of cognitive style. The design was such that these functions could be analyzed separately for males and females and separately by grade level. The stratifying variables and the dependent variables are described in the subsections below.

Item Analyses

The HFT, TIPT, and the CLP were each analyzed using the Generalized Item and Test Analysis Program (Baker, 1966). This program provides a test score for each individual, a frequency distribution of the test scores, summary statistics of the sample (such as N, $\bar{x}$, s_x, Σx, and Σx^2), the internal consistency reliability of the test by means of Hoyt's Analysis of Variance Method, and item statistics such as item difficulty and biserial r item-criterion correlation.

Correlational Study of the HFT

The HFT was further analyzed by intercorrelating the following 23 measures of the 16 items:

1. The number of Ss in grade six who got each item correct
2. The number of Ss in grade eight who got each item correct
3. The number of Ss in grade ten who got each item correct
4. The number of males who got each item correct
5. The number of females who got each item correct
6. The number of high HFT scorers who got each item correct
7. The number of low HFT scorers who got each item correct
8. The total number of Ss who got each item correct

9. The number of the item
10. The number of line segments making up the hidden figure
11. The number of minimal closed figures making up the pattern
12. The number of maximal line segments making up the pattern
13. The ratio of measure 10 to measure 11
14. The ratio of measure 10 to measure 12
15. The distance in millimeters of the gravitational center of the hidden figure from the gravitational center of the pattern
16. The number of lines of symmetry of the pattern
17. The area of the hidden figure
18. The area of the pattern
19. The ratio of measure 17 to measure 18
20. The number of minimal closed figures within the hidden figure
21. The number of intersections in the pattern
22. The variance of the line density in the pattern
23. The combination of measures 10, 13, 14, 17, and 19

Measures 6 and 7 above were determined as follows: The scores on the HFT represented the degree to which a S was analytical. The greater the S's analytical ability, the more items on the HFT he should answer correctly. Since all Ss were instructed to answer every item, a proportion of the number of correct items would be obtained through guessing. The probabilities of attaining scores of 0, 1, 2, 3, 4, 5, 6, and over 6 items correct by random guessing were .028, .113, .211, .246, .201, .120, .055, and .026, respectively. From these probabilities the author determined that any score of six or above represented a significant degree of analytical ability apart from guessing ability. All Ss who scored six or above were put into the category of "high HFT scorers," and all Ss who scored five or below were put into the category "low HFT scorers."

Measures 10 through 22 were quantifications of each item in the HFT. The author tried to view the HFT in an analytic manner to find which specific quality of the hidden figures required analysis by the S. It seemed that analysis of the pattern might be facilitated by greater amounts of relevant information and hindered by greater amounts of irrelevant information. Thus, Measures 10 and 17 were tabulations of the numbers of relevant lines and the relevant area of each figure, while Measures 11, 12, 18, 20, and 21 were tabulations of irrelevant lines, figures, and areas. Other measures such as symmetry, distance, pattern variance, and ratios of relevant to irrelevant information were also included as possible correlates of an analytical search.

Measure 23 was a combination of all the quantifications that involved the amount of relevant information. In this combination the three ratios were given a weight of 100 to remove the decimal point, and Measures 10 and 17 were given weights of 5 to make their magnitude approximately equal to that of the weighted ratios.

The intercorrelations of these 23 measures represented an attempt to find which variables would account for a significant amount of the score variance among HFT items. The correlations between the scores of groups of Ss (i.e. males vs. females; high vs. low HFT scorers; sixth vs. eighth vs. tenth graders) were also of interest, as were changes from group to group in the correlations obtained between various group scores and the quantification of the HFT items.

Intercorrelations of the HFT, TIPT, CLP, IQ, and GPA

A second correlational study was done in which the intercorrelations of eight variables were obtained for eight separate groups: sixth graders, eighth graders, tenth graders, males, females, high HFT scorers, low HFT scorers, and all Ss. The eight variables were:

1. Number correct on the HFT
2. IQ
3. Number correct on the CLP
4. Number correct on the TIPT
5. English GPA
6. Social studies GPA
7. Mathematics GPA
8. Total GPA

Analyses of Variance

A $2 \times 2 \times 3$ factorial analysis of variance design was used to analyze the data from 25 dependent variables. The factors in each analysis were HFT score, sex, and grade level. Table 1 presents the number of Ss in each cell. Each dependent variable was analyzed by using a general linear hypothesis computer program for analysis of variance with unequal cell frequencies. The dependent variables were as follows:

1. Number correct on the HFT
2. Otis or Lorge-Thorndike IQ score
3. English GPA
4. Social Studies GPA
5. Mathematics GPA
6. Total GPA

Table 1

Analysis of Variance Design

HFT Score	Sex	Grade Level Sixth	Eighth	Tenth
High	Female	n = 22	n = 24	n = 22
High	Male	n = 20	n = 19	n = 31
Low	Female	n = 24	n = 21	n = 15
Low	Male	n = 22	n = 18	n = 18
Totals:	Sixth n = 88 Eighth n = 82 Tenth n = 86	Females n = 128 Males n = 128		High n = 138 Low n = 118

7. Number of "Yes" items correct on TIPT[1]
8. Number of "No" items correct on TIPT
9. Number of "Can't Tell" items correct on TIPT
10. Number of errors on YES card[1]
11. Number of errors on NO card
12. "Can't Tell" errors on YES card
13. "Can't Tell" errors on NO card
14. "Yes" errors on YES card
15. "No" errors on NO card
16. Total numbers of items correct on the TIPT
17. Inclusion errors on CLP #1
18. Inclusion errors on CLP #2
19. Total inclusion errors
20. Exclusion errors on CLP #1
21. Exclusion errors on CLP #2
22. Total exclusion errors
23. Number correct on CLP #1
24. Number correct on CLP #2
25. Total number correct on CLP

[1] Throughout this paper "Yes," "No," and "Can't Tell" refer to the response to the item, YES or NO in capital letters refer to the type of card the S had to reason from.

IV
EXPERIMENTAL RESULTS AND DISCUSSION

ITEM ANALYSES

HFT

The 16 items of Part I of the HFT received 4050 responses from the 256 Ss. These 4050 responses were out of a possible 4096 responses that would have been obtained if the instructions to answer every item had been followed perfectly. Of the observed responses, 1473 were correct. This number was significantly above the chance level of 810 correct ($\chi^2 = 556.2$, $p < .001$, $df = 1$). The correct responses were distributed as shown in Table 2 in the column headed "Observed Number Correct." The number of possible correct responses for each of A, B, C, and D was 768, and the number possible for E was 1024. The wrong responses were distributed as shown in Table 3 in the column headed "Observed Guesses." The chi-square between observed and expected guesses was very high, implying that the wrong responses were definitely not randomly distributed. The options C and D received many more responses than chance, and A, B, and E received many fewer responses than chance, as shown in Table 3.

The guessing bias was used to obtain the "Corrected Observed Number Correct" column shown in Table 2. The chi-square value between the "Expected Number Correct" and the "Corrected Observed Number Correct" was large, and significant at the .001 level. This significant chi-square value means that when the option choices were corrected for guessing bias, the various figures were not equally easy to locate. Hidden Figure A was especially easy to find, while Figures D and E were somewhat harder to find than expected.

The difference in difficulty level may indicate that most Ss do not search the pattern for all the figures simultaneously, but rather look for one figure until satisfied that it isn't embedded in the pattern, and then they begin searching for another figure. Reading experience, which is always left to right, and the alphabetical labeling of the figures dictate that the most likely search method is to look for Figure A, then B, C, D, and finally E. The fact that a time limit existed for each pattern means that the search would be more often successful for items in which A, B, or C was hidden than for items holding D or E. This search may also be part of the explanation for the non-random guessing behavior demonstrated by the Ss. Options C and D were chosen significantly more often than A, B, and E. Does this imply that generally Ss had searched for A and B and not found them, and then ran out of time while looking for C or D, and as yet hadn't considered E? If so, it implies that the S would give as his answer the figure he was searching for when time ran out rather than a figure he had searched for and not found, and others he had no time to consider.

The mean number of correct responses on the HFT was 5.75 with a standard deviation of 2.60. The Hoyt internal consistency reliability measure was .496, each item showing a standard error of 1.79. The Hoyt analysis of the test was also used to determine whether the HFT differentiated individuals satisfactorily. The F ratio of individual variance to error variance was 1.99, which was significant beyond the .01 level for 255 and 3825 degrees of freedom (F ratio required, 1.24). This significant F ratio showed that the HFT measured sufficiently accurately to differentiate among individuals. The F ratio of item variance to error variance was 6.20, a highly significant ratio for 15 and 3825 degrees of freedom. This ratio implies that the mean score for at least one item was significantly different from the mean score for other items. A Scheffé test revealed several item comparisons as being significant at the .10 level. The results of the Scheffé test are presented in Table I of Appendix B. The mean, standard deviation, and the Hoyt statistics are summarized in Table 4 for the HFT, the TIPT, and CLP.

Table 5 gives the frequency distribution of the Ss' scores on the HFT, TIPT, and CLP.

Table 2

Expected Number of Correct A, B, C, D, and E Items Compared to Observed Number, Corrected for Guessing Bias

Correct Response	Expected Number Correct	Corrected Observed Number Correct	Observed Number Correct
A	221	281	336
B	221	216	262
C	221	224	308
D	221	195	251
E	295	264	316
Total	1179	1180	1473

Note: The correction for guessing factor was determined as follows: The distribution of wrong responses in Table 3 gave the proportion of guesses for A, B, C, D, and E as 16.5, 17.7, 27.3, 22.2, and 16.3 percent, respectively. This percentage was multiplied times the observed number correct, and the resulting value was subtracted from the observed number correct to give the corrected observed value in Table 2. The total of these corrected observed numbers (1180) was used as the basis of the "Expected Number Correct" column. The expected column contains the approximate number of correct responses for each option if the 1180 "corrected" correct responses had been randomly distributed.

$\chi^2 = 22.72$, $p < .001$, df = 4

Table 3

Expected and Observed Number of A, B, C, D, and E Error Responses on the HFT

Item Response	Expected Guesses	Observed Guesses
A	538	426
B	520	457
C	532	704
D	518	571
E	469	419
Total	2577	2577

Note: The expected guesses were calculated item by item. For item #1, for example, there were 134 guesses which by chance would have been distributed equally among responses B, C, D, and E. This calculation procedure, though based on an expectation of random distribution of wrong responses, led to varying expectations for the response options.

$\chi^2 = 97.30$, $p < .001$, df = 4

Note that for the HFT the frequency distribution resulted in a very good approximation to a normal distribution with only a slight positive skew. In the methodology section a decision was made to regard any score of six or above as evidence of a significant degree of analytical ability. From the frequency distribution it can be seen that 138 Ss fell within this analytical group while 118 were below it. Although this was not a median split, it was acceptable for defining the high and low HFT groups that were used as a factor in the analysis of variance.

In Table 6 are given (a) the biserial correlation coefficient between each correct item response and the total test score, (b) the difficulty of each item as the percentage of Ss who answered correctly, and (c) the correct answer for each item in each of the three tests. All of the items of the HFT made some contribution to the reliability of the total instrument, as shown by the biserial coefficients. The items were generally very difficult since only Item 16 reached the point of 50% correct responses. This criticism of the difficulty level is attenuated by the fact that the test was given to groups that were younger than the college freshman level, this being the level that the HFT is normally used with.

Table 4

Means, Standard Deviations, and Hoyt Reliability Statistics for the HFT, TIPT, and CLP

Statistic	HFT	TIPT	CLP
Mean Number Correct	5.75	14.13	18.28
Standard Deviation of Test	2.60	4.61	3.04
Hoyt Internal Consistency Reliability	.496	.686	.651
Standard Error of Items	1.79	2.54	1.76
Ratio of Individual Variance to Error Variance	1.99**	3.19**	2.87**
Ratio of Item Variance to Error Variance	6.20**	13.14**	73.94**

**p < .01

Table 5

Expected and Observed Frequency Distribution of the Scores on the Hidden Figures Test (HFT), the Tagatz Information Processing Test (TIPT), and the Concept Learning Problems (CLP)

Number	HFT (16 items)		TIPT (30 items)		CLP (24 items)	
Correct	Observed	Chance	Observed	Chance	Observed	Chance
0	1	7	-	-	-	-
1	9	29	-	-	-	-
2	18	54	-	-	-	-
3	25	63	-	-	-	-
4	29	51	-	2	-	-
5	36	31	2	6	-	1
6	49	14	3	12	-	2
7	29	6	9	21	-	5
8	25	1	6	31	-	11
9	13	-	18	37	2	20
10	9	-	17	39	-	30
11	6	-	25	36	1	38
12	5	-	25	28	8	42
13	2	-	28	20	4	38
14	-	-	18	12	9	30
15	-	-	17	6	18	20
16	-	-	16	3	21	11
17			18	1	34	5
18			9	-	52	2
19			11	-	25	1
20			8	-	26	-
21			6	-	16	-
22			5	-	14	-
23			5	-	7	-
24			-	-	19	-
25			7	-		
26			-	-		
27			2	-		
28			1	-		
29			-	-		
30			-	-		

Table 6

Answer, Percent of $\underline{S}$s Getting an Item Correct, and Biserial r Item-Test Reliability for Items in the HFT, TIPT, and CLP

Item Number	HFT			TIPT			CLP		
	r_{bi}	%	ans.	r_{bi}	%	ans.	r_{bi}	%	ans.
1	.48	47	A	.35	49	N	.54	65	N
2	.51	40	B	.54	57	Y	.33	91	N
3	.59	37	E	.27	64	CT	.32	95	N
4	.59	33	D	.55	49	Y	.58	90	N
5	.45	29	B	.15	47	N	.50	41	Y
6	.36	33	D	.63	45	Y	.56	41	Y
7	.57	27	E	.49	53	N	.40	81	N
8	.50	43	A	.49	41	Y	.42	60	N
9	.36	33	B	.23	52	CT	.44	97	N
10	.30	32	D	.33	32	CT	.61	89	N
11	.53	42	C	.31	52	N	.50	88	Y
12	.51	42	A	.53	53	Y	.43	92	N
13	.36	27	E	.32	31	CT	.54	92	N
14	.29	32	E	-.02	39	CT	.49	47	Y
15	.25	28	C	.19	25	CT	.53	56	Y
16	.37	50	C	.50	24	Y	.47	90	N
17				.34	32	CT	.50	71	Y
18				.56	34	Y	.55	88	N
19				.53	55	N	.46	49	Y
20				.59	44	Y	.63	93	N
21				.42	53	N	.50	87	N
22				.31	58	N	.66	89	N
23				.49	47	N	.55	45	Y
24				.30	49	CT	.50	89	N
25				.38	53	N			
26				.32	48	N			
27				.51	62	Y			
28				.48	45	CT			
29				.50	61	Y			
30				.36	59	CT			

Y = Yes N = No CT = Can't Tell

TIPT

The 30 items of the TIPT received 7673 responses c of a possible 7680. Of these 7673 responses, 3618 were correct; but 621 of the responses were first level inclusion errors (i.e. $\underline{S}$s said a card was "Yes" when the correct answer was "Can't Tell"), 841 were first level exclusion errors ($\underline{S}$s said "No" when the correct answer was "Can't Tell"), 1654 were "Can't Tell" errors ($\underline{S}$s said "Can't Tell" when the correct response was "Yes" or "No"), 369 were second level inclusion errors ($\underline{S}$s said "Yes" when "No" was correct), and 570 were second level exclusion errors ($\underline{S}$s said "No" when "Yes" was correct). These errors and the expected number of errors of each type are summarized in Table 7. The chi-square for the expected-observed comparison was large and significant, which showed that errors were not random but that $\underline{S}$s were making more "Can't Tell" and first level exclusion errors than expected. The observed number correct, 3618, was significantly above the chance level of 2558 correct ($\chi^2 = 658.8$, $p < .001$, df = 1).

The total numbers of inclusion, exclusion, and "Can't Tell" errors are presented in Table 8 for the TIPT and the CLP. The number of inclusion errors per item was higher on the TIPT than on the CLP, while the number of exclusion errors per item was lower on the TIPT than on the CLP.

Table 4 contains the mean, standard deviation, and the Hoyt reliability data for the TIPT. The Hoyt reliability coefficient of .686 for the

Table 7

Expected and Observed Number of Error Responses on the TIPT

Type of Error	Expected	Observed
First Level Inclusion (Ss said "Yes" when "Can't Tell" was correct)	731	621
First Level Exclusion (Ss said "No" when "Can't Tell" was correct)	731	841
Second Level Inclusion (Ss said "Yes" when "No" was correct)	620	369
Second Level Exclusion (Ss said "No" when "Yes" was correct)	676.5	570
Indecision (Ss said "Can't Tell" when "Yes" or "No" was correct)	1296.5	1654
Total	4055	4055

$\chi^2 = 250.06$, $p < .001$, df = 4

Table 8

Inclusion Errors, Exclusion Errors, and Errors of Indecision on Concept Learning Problem #1 and #2, and on the Tagatz Information Processing Test

Errors	CLP #1	CLP #2	TIPT
Inclusion (Ss said "Yes" when "No" or "Can't Tell" was correct)			
Total Number	351	179	990
Number per Item	39.0	25.6	49.5
Exclusion (Ss said "No" when "Yes" or "Can't Tell" was correct)			
Total Number	329	592	1411
Number per Item	109.7	118.4	70.6
Indecision (Ss said "Can't Tell" when "Yes" or "No" was correct)			
Total Number	-	-	1654
Number per Item	-	-	82.7

TIPT was higher than that for either the HFT or the CLP. The large ratio of individual variance to error variance showed that the test discriminated well among Ss. The F ratio for item variance was significant showing that some items of the test were easier than other items. A Scheffé test revealed many significantly different pairs of items. A summary of these Scheffé comparisons is presented in Table II of Appendix B.

The frequency distribution of each of the tests is presented in Table 5. The distribution of the TIPT had a positive skew and a range of 5 to 28 correct. Any score over 13 had less than a .05 probability of occurring by chance. Nearly half (123 of 256) of the Ss scored over 13 correct. In Table 6 the biserial r and the difficulty for each item in the TIPT are presented. Several items (Numbers 5, 9, 14, 15) had a very low item-criterion correlation. These probably should be re-examined and improved.

Table 9 shows the average difficulty and reliability of subsets of the 30 items on the TIPT. The 15 items in which Ss had to reason from a YES card were more difficult and also more reliable than the 15 items in which Ss

Table 9

Average Difficulty and Reliability of "Yes," "No," and "Can't Tell" Items, and of YES Card and NO Card Items on the TIPT and CLP

Items (Number of Items)	Difficulty (% Correct)	Average Reliability
TIPT		
YES Card (15)	42	.44
NO Card (15)	52	.36
"Yes" Response (10)	47	.54
"No" Response (10)	51	.34
"Can't Tell" Response (10)	43	.28
CLP		
"Yes" Response (8)	55	.51
"No" Response (16)	87	.50

had to reason from a NO card. When the items for which "Yes" was the correct answer were compared to the "No" and "Can't Tell" items, the "No" items were easiest and the "Yes" items had the highest average biserial coefficient. The "Can't Tell" items were the most difficult and least reliable.

CLP

The two problems of the CLP (Concept Learning Problems) each consisted of 12 items. These 24 items were treated as one test for the item analysis. The mean, standard deviation, and Hoyt statistics are given in Table 4. The Hoyt reliability of .651 was nearly equal to that of the TIPT, and was above that of the HFT. The F ratios for individual variance and item variance to error variance were each significant beyond the .01 level. The significant ratios showed that the test discriminated very well among Ss and that some items were significantly more difficult than other items. Table 6, which gives the difficulty level of the items, shows that the "Yes" items were systematically more difficult than the "No" items. Table 8 verifies that Ss made many more exclusion errors than inclusion errors. A Scheffé test, presented in Table III of Appendix B, shows which items were significantly different from other items at the .01 level.

The expected and observed frequency distributions of scores are shown in Table 5. The Ss' average score was much above the chance level; in fact the observed distribution was bimodal due to a large number of perfect scores.

Table 6 presents the item difficulty and the item-criterion correlation. All the items contributed to the reliability of the test. The "Yes" items were more difficult than the "No" items, as shown in Table 6 and Table 9. The average "No" item was answered correctly by 87% of the Ss, but only 55% answered the average "Yes" item correctly. The latter percentage was barely above the chance level of 50%. The "Yes" items on the TIPT were also somewhat more difficult than the "No" items. A proposed explanation for the greater difficulty of the "Yes" items is that Ss have a distinct tendency to make exclusion errors rather than inclusion errors; that is, they will exclude unless the object in question meets the criteria for inclusion. This view is supported by the higher rate of exclusion errors than inclusion errors shown in both the CLP and the TIPT (Tables 7 and 8). The logic behind the tendency to exclude may be based on the Ss' ability to articulate the field. Assuming a wide range of ability in articulation, which is a reasonable assumption on the basis of the work in field-dependence-independence, and keeping in mind that exclusion need be based upon only one dimension while inclusion often requires that several criteria be met, it follows that the ability to avoid inclusion errors is a lower level task than avoiding exclusion errors. More Ss would be successful in the former than in the latter. In other words, a person with limited abilities in distinguishing relevant and irrelevant information could often make decisions to exclude and know he was correct, but his limited abilities would keep him from knowing with certainty whether an object could correctly be included.

This inability to adequately determine inclusion of an object was reflected in the difficulty level of sets of items in the CLP. An item in the CLP which met neither of the criteria for inclusion was easily excluded. If an item met one of the criteria, this fact increased the difficulty, though the item would still probably be properly excluded. A "Yes" item, meeting both criteria and requiring recognition of this fact, proved most difficult. There were six items in the CLP that met neither criteria for inclusion, and the average percent of Ss getting these items correct was 93; the ten items that met only one of the criteria had an average percent of 83 correct, while the eight items meeting both criteria were answered correctly by only 55% of the Ss. Evidence for a bias toward exclusion was seen in the error responses on the TIPT. When an item was indeterminate, i.e., "Can't Tell," 58% of the errors were exclusion errors compared to 42% inclusion errors. When an item was "Yes" or "No," 22% of the errors were exclusion compared to 14% inclusion. Of all the errors on the TIPT, inclusion, exclusion, and indecision, accounted for 24, 35, and 41% of the errors, respectively, as can be determined from Table 7 or Table 8.

CORRELATIONAL ANALYSIS OF THE HFT

The HFT is purported to measure analytical ability. For one or more reasons the figure embedded in the pattern is difficult to find and the pattern must be carefully analyzed. It was the purpose of this correlational study of the HFT to determine what aspects of the figure-pattern complex were possible correlates of successful analysis. Fifteen measures of the items in the HFT were obtained. These measures were the number of intersections in each pattern, the area of the figure, the number of closed figures in the pattern, and other similar measures. Other measures were ratios of relevant and irrelevant information. One measure was a combination of all the measures that involved the amount of relevant information.

The 15 measures of each item were tabulated and entered in columns as shown in Table IV of Appendix B. The total numbers of Ss who got each item correct were obtained and entered in the same table. The total numbers were divided into subtotals for males and females; sixth, eighth, and tenth graders; and high and low scorers. These subtotals were the 8 dependent measures, which were correlated with the 15 independent measures of the items. The resulting correlations are presented in Tables 10, 11, and 12. Correlations of .34 or higher were significant at the .20 level; correlations of .43 or higher were significant at the .10 level; .50 was significant at the .05 level; and .58 at the .01 level. Roughly these same values will give the approximate significance of differences between correlations.

Variables 1 – 8, Dependent Measures

In Table 10 the intercorrelation of the 8 dependent measures are shown. In the comparison of the sixth, eighth, and tenth graders, only the correlation of .72 between tenth and eighth graders reached an acceptable level of significance. This implies either that at sixth grade the HFT was measuring abilities that had changed by the time Ss reached eighth and tenth grades, or that the items were viewed differently by sixth graders than by eighth and tenth graders. The correlation between males and females was high and significant ($r = .74$, $p < .01$), but not high enough to decide any and all arguments about the differential amounts and types of cognitive style possessed by males and females. The comparison of high scorers to low scorers also showed a significant correlation of .58 ($p < .01$). This value, although it suggests a large amount of commonality, leaves open the question of important differences between high and low scorers in the way they attack and analyze items of the HFT.

Variable 9

Table 11 consists of the correlations of the dependent and independent measures. Variable 9 was the number of the item. It was expected that if the HFT was constructed with more difficult items later in the test, the dependent variables would correlate positively with Variable 9. If Ss improved with practice a positive correlation would result. If Ss became fatigued as they worked through the items a negative correlation might result. The results showed that the correlation of item number with each of the dependent Variables 1 to 8 was minimal and not significant in any case. Unless the possibilities above neatly cancelled out each other, the best interpretation of this lack of significance is that the position of the item in the test was largely irrelevant to performance on that item.

Variable 10

Variable 10 was simply a count of the number of line segments making up the figure embedded in the pattern. This variable ranged from four line segments for Figures B and D, to six segments for A and E, to seven for Figure C. The number of line segments had a correlation of .33 with the number correct

Table 10

Correlations of the Eight Measures of Group Performance on the HFT

Group	1	2	3	4	5	6	7	8
1. Sixth Graders	-							
2. Eighth Graders	.42	-						
3. Tenth Graders	.32	.72	-					
4. Males	.50	.83	.86	-				
5. Females	.74	.83	.73	.74	-			
6. High HFT scorers	.58	.88	.82	.88	.89	-		
7. Low HFT scorers	.65	.65	.69	.72	.80	.58	-	
8. All Ss	.68	.89	.86	.91	.95	.94	.82	-

Table 11

Correlations of the Quantifications of the Items of the HFT with the Group Performance Measures

Independent Variable	1 6th	2 8th	3 10th	4 Male	5 Female	6 High	7 Low	8 All
9. Number of the Item	.02	-.04	-.16	-.08	-.07	-.17	.10	-.08
10. No. of lines in figure	.41	.35	.08	.26	.34	.36	.19	.33
11. No. of closed figures in pattern	-.40	.01	.12	-.07	-.10	-.16	.05	-.09
12. No. of lines in pattern	-.50	-.31	-.06	-.28	-.34	-.42	-.11	-.34
13. Ratio of 10 to 11	.58	.26	-.01	.18	.37	.35	.15	.31
14. Ratio of 10 to 12	.56	.44	.09	.34	.44	.50	.17	.43
15. Distance from center	-.11	-.39	-.17	-.27	-.26	-.27	-.22	-.28
16. Lines of symmetry	-.02	.27	.20	.14	.21	.11	.28	.19
17. Area of figure	.32	.41	.41	.44	.44	.42	.42	.47
18. Area of pattern	-.04	.02	.04	.03	-.01	-.08	.17	.01
19. Ratio of 17 to 18	.29	.28	.21	.30	.30	.38	.12	.32
20. Closed figures within figure	-.04	.10	.17	.08	.11	.06	.15	.10
21. Intersections	-.37	-.28	-.09	-.24	-.30	-.40	-.03	-.29
22. Variance of line density	-.44	.01	.12	-.04	-.14	-.14	-.02	-.10
23. Combination of 10, 13, 14, 17, 19	.64	.48	.16	.40	.52	.55	.27	.50

made by all the Ss on each item. Though this value was not significant, the way the various groups were affected by the number of relevant line segments is of interest. Sixth graders' performance correlated .41 with this variable, while eighth graders' correlated .35 and tenth graders' .08. One might also note that the performance of the high group correlated higher with this variable than did the low group. As the number of relevant lines increased, more sixth graders, eighth graders, and high scorers were able to find the hidden figure. The tenth graders were not so affected; their performance as a group depended on factors other than the number of relevant lines.

The fact that Variable 10 could range among only three values means that the observed correlations were lower than could be expected if a greater range of values had been included. In other words, the "real" correlation between number of line segments and performance might have been considerably above .33 if the range tested had been from two to ten. A problem exists in the interpretation of the decrease in the correlation coefficient with increase in $\underline{S}$s' age, experience, and presumably analytical ability. The correlation of the high scorers' performance with the number of relevant line segments represented the fact that the analytical ability of the high scorers was somewhat more successful when the amount of relevant information was greater. The low scorers were never very successful and the success they did have was less dependent upon the amounts of relevant information. When comparing high and low scorers on other variables, the performance of the high scorers consistently correlated more highly than the performance of low scorers with other measures of relevant information and measures of the ratio of relevant to irrelevant information.

The literature has revealed that analytical ability increases with age. It would be expected that the amount of relevant information would predict success better for tenth graders than for sixth graders, by virtue of the latter being younger and therefore less analytical, but the opposite is the case. The problem that needs explanation is that sixth graders look like the high analytical group, when theoretically and experimentally they are lower in analytical ability and score lower on the HFT than tenth graders.

One explanation of this problem involves assuming that the tenth graders were less motivated than the younger $\underline{S}$s and did not use their powers of analysis in the HFT. This would explain why their performance was uncorrelated with the amount of relevant information. This explanation, however, ignores a fact that arises later in this paper, viz. the tenth graders scored significantly higher on the HFT than did the sixth and eighth graders. In order to accomplish this feat, the tenth graders had to be analytical.

A second explanation, though admittedly very tenuous, takes into account the Piagetian view that sixth graders are only just learning to be analytical. The group of high scorers included $\underline{S}$s from all three grades. The numbers of sixth, eighth, and tenth graders in the high group were 42, 43, and 53, respectively. The correlation between Variable 10 and the performance of the high HFT group can be interpreted as due largely to the sixth and eighth grade high scorers, thereby implying that the correlations of the sixth and eighth grade groups with Variable 10 was also largely due to the high scorers in each group. This latter implication follows also from the idea that the performance of nonanalytic $\underline{S}$s is uncorrelated with amount of information, so that any correlation that is shown by a group results from the performance of the analytical $\underline{S}$s within the group. The developing analytical ability of the sixth graders and eighth graders is sensitive to the amount of relevant information. The more that is available, the better they can operate against large amounts of irrelevant information. At tenth grade the analytical ability is developed to a level that is sufficient to handle all problems of the HFT to an equal degree. They have developed the ability to articulate relevant from irrelevant information independently of the amount of relevant information. Sixth graders also are developing this ability, but it is at a level where more relevant information will make them more efficient and successful than little relevant information.

The correlational pattern shown by Variable 10 was indicative of and analogous to several other patterns of correlations that were obtained, especially those of Variables 13, 14, and 23 and the inverse of Variables 12 and 21. For these reasons it was felt useful to present some tentative explanations at this point, and then refer to them later as they gained support from other data.

Variable 11

Variable 11 was a tabulation of the number of minimal closed figures that a pattern contained. On an 8×8 checkerboard pattern this number would be 64. If the $\underline{S}$s' analysis of the HFT patterns proceeded in each case by the $\underline{S}$s attempting to build the embedded figure by combining adjoining minimal closed figures, then the number of these figures would give a good indication of the amount of analysis required. The more such minimal figures, that is, the more irrelevant information, the less successful analysis should be and hence correlations with this variable should be negative. Seven of the correlations showed absolutely no significant relationship. Only the correlation of this variable with the sixth-grade group suggested the expected relation. His correlation of $-.40$ was not significant at the .05 level, but its direction was consistent with the interpretation that sixth graders are at a level in the development of their analytical abilities which is not quite adequate to articulate relevant from irrelevant information when the amount of relevant information is low or the amount of irrelevant information is high.

Variable 12

Variable 12 was another measure of the amount of irrelevant information in a pattern. It correlated .61 with Variable 11 and negatively ($r = -.34$) with $\underline{S}$s' performance. As with

Variable 10, the pattern of the correlations between Variable 12 and the dependent measures required an interpretation which was based on the developing analytical ability of the Ss. Though Variables 10 and 12 were uncorrelated ($r = -.12$), the absolute values of the correlations involving these two variables with the dependent measures showed a strikingly similar pattern. The correlational pattern of Variable 12 revealed that the performance of sixth graders was significantly affected by the number of lines in the pattern ($p < .05$); eighth graders were affected less so although in a similar direction, and tenth graders were coping equally well with all the items, whether the items were high or low in numbers of irrelevant lines. Again, males and females were equally affected and the high group correlated higher with Variable 12 than did the low group. The number of irrelevant line segments correlated with performance in the same way that the number of relevant line segments did, only in the opposite direction. The interpretation used for Variable 10 was supported and also extended by the results of Variable 12. It appears that the level at which sixth and eighth graders analyze does not work equally well for all levels of relevant and irrelevant information. At sixth grade Ss who are developing those powers of analysis required by the HFT are at a point which is reasonably successful when finding a large amount of relevant information embedded in a small amount of irrelevant information. But when small amounts of relevant information are to be found within larger amounts of irrelevant, the sixth graders are inefficient, their analytical level is insufficient. As Ss grow older, their ability to analyze, to articulate relevant from irrelevant, becomes less dependent upon the absolute amounts of each kind of information.

Variables 13 and 14

It might be expected that the ratio of relevant to irrelevant information is the quantity that sixth graders are more sensitive to than older Ss. Variables 13 and 14 were such ratios, and the pattern of correlations that each showed clearly supported the developmental interpretation. Variable 14, the ratio of relevant to irrelevant lines, correlated .43 with the overall performance of all the Ss. This means that at the .10 level of confidence there was some assurance that a relation between this ratio and performance existed. When the Ss were grouped into high and low categories it was evident that only the high group was sensitive to the ratio. Grouping Ss by sexes showed no significant difference in the sensitivity to the ratio. There was a clear descending association between the ratio and performance as the Ss' ages increased. At sixth grade the ratio of relevant to irrelevant information was critical enough to show a significant correlation with performance ($p < .02$), while at eighth grade the correlation dropped to .44 ($p < .10$) and at tenth grade to an insignificant .09.

Variable 15

Variable 15 was a measure of the distance in millimeters from the center of the pattern to the center of the figure hidden in the pattern. It might be expected that as this distance increased the figure would be more difficult to locate, especially if the search procedure used by the Ss began in the center of the pattern and then moved to the extremities. The correlations of this variable with performance were all negative implying that figures hidden closer to the center of the pattern were somewhat easier to find but not significantly so.

Variable 16

Variable 16 was simply a count of the number of lines of symmetry shown by each pattern. No clear or significant correlations and no consistent pattern of correlations emerged with this variable. It might have been postulated that either (a) symmetry, by providing a mirror image of the hidden figure, would help the Ss find the figure, or (b) symmetry would give the pattern a good Gestalt which would make it more difficult to analyze. The generally positive correlations of this variable suggested that (b) was definitely not the case, and that while (a) was possible, the evidence for it was very weak.

Variables 17, 18, and 19

The area of the figure, Variable 17, was another approximation to the amount of relevant information, and correlations with this variable were expected to be positive. The results in Table 11 show that Variable 17 correlated positively with performance as expected, and that the area measure was one of the better independent variables of all those used. All groups reacted nearly equally to the amount of relevant area. The area of the pattern, Variable 18, however, showed no correlation with performance, and Variable 19, which was the ratio of 17 to 18, showed the correlations it did largely on the strength of Variable 17.

Variable 20

Variable 20, the number of minimal closed figures which were within the figure as it was embedded in the pattern, did not correlate significantly with the performance of the Ss.

Variable 21

Variable 21 was the number of intersections in the pattern and was another measure of irrelevant information. If each intersection represented a decision point at which the S must decide whether a corner of a hidden figure coincides with the lines forming the intersection, then the more intersections, the more possible points of decision and coincidence, the more analysis should suffer. The correlations between Variable 21 and the dependent measures were generally negative and showed the same pattern of relationship to the groups that Variable 12 showed. It would seem that Variable 21 provided an additional piece of evidence consistent with the developmental explanation offered previously.

Variable 22

Variable 22 was a measure of the variance of the line density in each pattern. Each pattern was covered by a grid of lines, the lines in the grid being constructed to touch the points of intersection in the pattern. The line segments of the pattern within or touching each square of the grid were counted. This number ranged from zero line segments to six line segments within a square of the grid. The variance of the numbers of the lines in each grid was obtained and multiplied by 100 to remove the decimal point. A task which requires considerable processing of information should be easier when the variability of the information is low. A regular, repetitious pattern should be easier to analyze than a pattern in which some squares contain many lines and others few. The results showed that Variable 22 had little relation to the ease or difficulty of finding the hidden figures, except for the group of sixth graders. The sixth graders had more difficulty finding the hidden figures as the variance of the line density increased ($p < .10$). This fact is consistent with an interpretation that assumes that these young Ss have only a rather tenuous grip on their analytical abilities.

Variable 23

The final independent variable was a combination of Variables 10, 13, 14, 17, and 19. This combination included the two variables which were measures of relevant information, and the three ratios of relevant to irrelevant information. The ratios were given a weight of 100 to remove the decimal point, and the other two measures were given a weight of five to make their means equivalent to the means of the weighted ratios. This canonical variable correlated with performance the most highly of any of the independent variables selected for study. Variable 23 gave the clearest and most significant support to the developmental interpretation. It accounted for one-fourth of the total variance, and 40% of the variance of the sixth-grade group. Its pattern of correlations, along with the reflected patterns obtained from the measures of irrelevant information (namely, 12 and 21), provided a consistent framework for interpreting what the HFT measured. At sixth grade and somewhat at eighth grade, the Ss' performance was dependent on relative and absolute amounts of relevant and irrelevant information. By the time the Ss reached tenth grade, the correlates of performance were no longer clear. Whatever the HFT measured in the group of tenth graders, the extensive list of variables used in the present study gave little hint of what it might be. Apparently the tenth graders have reached an efficient level of analysis, but their success on individual items depends largely on chance factors or an unquantifiable Gestalt view of each pattern.

Independent Variables 9 – 23

Table 12 gives the intercorrelations of the 15 independent variables. The table is presented without additional comment since it needs little explanation and is included only to help the reader determine the relatedness of the independent variables when considering each variable in relation to the Ss' performance.

CORRELATIONAL STUDY OF IQ, GPA, AND THE THREE TESTS

Eight variables were selected for a correlational study. These eight variables were the IQ; GPA in each of English, social studies, and mathematics and a combined GPA; and scores on the HFT, the TIPT, and the CLP. These eight variables were intercorrelated using the descriptive statistics program of the University of Wisconsin Computing Center. The program was used eight times, once for all 256 Ss, and once each for the high HFT group, the low HFT group, males, females,

Table 12

Correlations of the 15 Quantifications of the Items in the HFT

Variable	10	11	12	13	14	15	16	17	18	19	20	21	22	23
9. Item Number	.54	.37	.22	-.08	.24	-.22	-.14	.18	.35	-.16	.30	.52	.35	.19
10. Relevant Lines	-	-.11	-.12	.60	.73	-.09	.00	.22	-.02	.18	.06	.02	.07	.80
11. Irrelevant Figures		-	.61	-.81	-.43	-.52	-.20	.17	.30	-.20	.72	.82	.58	-.50
12. Irrelevant Lines			-	-.49	-.74	-.05	.12	.25	.27	-.12	.28	.70	.62	-.46
13. Ratio 10/11				-	.69	.30	.25	.09	-.29	.34	-.46	-.67	-.43	.85
14. Ratio 10/12					-	-.11	-.06	.00	-.26	.26	-.04	-.43	-.35	.84
15. Distance						-	.02	-.40	.24	-.44	-.74	-.29	-.05	-.10
16. Symmetry							-	.09	.09	-.07	-.32	-.16	-.24	.08
17. Area of Figure								-	.10	.58	.43	.22	.40	.39
18. Area of Pattern									-	-.74	-.23	.40	.26	-.33
19. Ratio 17/18										-	.40	-.26	-.00	.56
20. Figures in Figure											-	.55	.37	-.02
21. Intersections												-	.69	-.42
22. Variance													-	-.20
23. Combination														-

sixth, eighth, and tenth graders. The resulting correlations of the eight variables for the eight groups are given in Table 13. The levels of significance of each correlation are given by the asterisks.

Note that IQ and the HFT score were significantly correlated ($r = .38$, $p < .01$), as were HFT and total GPA ($r = .26$, $p < .01$). The correlations of the HFT with the CLP and TIPT, although significant, were small ($r = .15$, $p < .05$; $r = .24$, $p < .01$, respectively). The correlations between sets of grades were very high, being .70 between English and social studies, .56 between English and mathematics, and .55 between social studies and mathematics ($p < .01$).

By treating various pairs of correlations within the group of all Ss as having been obtained from correlated samples,[2] the significance of differences between various correlations was obtained. IQ was a significantly better predictor of HFT score than was GPA ($t = 2.21$, $p < .05$). GPA and IQ were not significantly different in predicting CLP score ($t = 1.75$, $p > .05$), or in predicting TIPT score ($t = 1.79$, $p > .05$). The CLP and TIPT were not significantly different in predicting HFT scores ($t = 1.16$, $p > .05$). English and social studies correlated higher with the total GPA than did mathematics ($t = 3.86$ for English-mathematics comparison, and $t = 3.31$ for social studies-mathematics comparison, $p < .01$), while all three course grades correlated equally well with IQ.

By treating the correlation of the high and low HFT groups as independent samples,[3] the significance of differences between corresponding correlation coefficients of the two groups was obtained. Only one difference between the high HFT and low HFT groups was significant, and this was the correlation of social studies grade with total GPA. Using the same significance test for differences between two correlation coefficients for independent samples, the differences between males and females were also tested. No significant differences in correlations for males and females were found. This same test was used for the differences between grade levels. Twenty of these comparisons were significant, seven at the .01 level. Each comparison that was significant at the .05 level is marked in Table 13, with "a" representing the high value and "b" representing the low value. If the difference was significant at the .01 level, a "c" is used along with a "d."

The first of these 20 differences was between the eighth and tenth grade correlations of the HFT with the TIPT. The interpretation of this difference relates the kind of reasoning the TIPT and HFT have in common at various grade levels. There is no evidence that performance on the TIPT and HFT correlated in the sixth and eighth grade, but at tenth grade a significant amount of commonality existed between the information handling used on each test so that a significant correlation ($r = .35$, $p < .01$) resulted.

The second and third differences were in the correlations of IQ with CLP score. The correlations for the sixth and tenth grades were significant ($p < .01$), while that for the eighth grade was zero and significantly less than the other two grades. The reason for the low eighth grade correlation is unknown.

The fourth significant difference was between sixth and tenth graders on the correlation of IQ with TIPT score. Sixth graders showed a coefficient of .15, eighth graders .27, and tenth graders .44, the latter two being significant ($p < .01$). The increase in correlation across grades seems to support and extend the interpretation of the first difference above. As age increases, the ability that the TIPT measures becomes increasingly correlated with the abilities involved in intelligence. The kind of information processing that a tenth grader uses may well be regarded as more rigorous and intellectually based than that which is used by sixth and eighth graders.

The next two differences were from correlations of IQ with GPA. These were not experimentally induced and may simply reflect different emphases of the respective teachers and schools and IQ tests.

The next two differences were from correlations of the CLP with the TIPT. The correlation increased as the age increased, which is the same relation that the TIPT had to IQ. By tenth

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[2] Significance of the difference between two correlation coefficients for correlated samples (Ferguson, 1959, p. 154).

$$t = \frac{(r_{12} - r_{13})\sqrt{(N-3)(1+r_{23})}}{\sqrt{2(1 - r_{12}^2 - r_{13}^2 - r_{23}^2 + 2r_{12}r_{13}r_{23})}}$$

$$t_{.05}(253) = 1.98$$

$$t_{.01}(253) = 2.61.$$

[3] Significance of the differences between two correlation coefficients for independent samples (Ferguson, 1959, p. 154).

$$z = \frac{z_{r1} - z_{r2}}{\sqrt{1/(N_1-3) + 1/(N_2-3)}}$$

$$Z_{.05} = 1.96$$

$$Z_{.01} = 2.58$$

Table 13

Correlations of Eight Variables for All Ss, High and Low HFT Scorers, Males and Females, and Sixth, Eighth, and Tenth Graders

Group	HGT and IQ	HFT and CLP	HFT and TIPT	HFT and ENG	HFT and SS	HFT and MATH	HFT and TOTAL	IQ and CLP	IQ and TIPT	IQ and ENG	IQ and SS	IQ and MATH	IQ and TOTAL	CLP and TIPT
All Ss	.38**	-.15*	.24**	.21**	.23**	.22**	.26**	.25**	.30**	.50**	.50**	.44**	.56**	.18**
High	.27**	.07	.21**	.04	.15	.16	.13	.25**	.34**	.43**	.49**	.41**	.51**	.16
Low	.24**	-.09	.07	.10	.13	-.02	.08	.16	.18*	.52**	.47**	.40**	.55**	.16
Males	.38**	.09	.17	.22**	.18*	.25**	.25**	.27**	.22**	.45**	.46**	.47**	.53**	.29**
Females	.43**	.23**	.34**	.25**	.31**	.18*	.30**	.20*	.36**	.53**	.52**	.42**	.58**	.07
Sixth	34**	.18	.16	.26*	.19	.30**	.30**	.32**a	.15b	.59**	.46**	.63**c	.67**	-.05d
Eighth	.42**	.07	.04b	.35**	.27**	.30**	.34**	.00b	.27**	.66**a	.60**	.54**	.66**	.11b
Tenth	.40**	.17	.35**a	.13	.31**	.08	.21*	.33**a	.44**a	.42**b	.55**	.27**d	.51**	.40**ac

Group	CLP and ENG	CLP and SS	CLP and MATH	CLP and TOTAL	TIPT and ENG	TIPT and SS	TIPT and MATH	TIPT and TOTAL	ENG and SS	ENG and MATH	ENG and TOTAL	SS and MATH	SS and TOTAL	MATH and TOTAL
All Ss	.12	.14*	.12*	.15*	.16**	.20**	.15**	.20**	.70**	.56**	.88**	.55**	.87**	.82**
High	.06	.10	.01	.07	.06	.16	.11	.13	.71**	.53**	.87**	.60**	.90**a	.82**
Low	.12	.14	.18*	.18	.23**	.20*	.14	.23**	.65**	.54**	.88**	.44**	.82**b	.80**
Males	.13	.12	.16	.15	.05	.09	.16	.11	.73**	.63**	.90**	.58**	.88**	.84**
Females	.09	.16	.08	.13	.23**	.29**	.16	.27**	.65**	.50**	.85**	.53**	.87**	.81**
Sixth	.23*a	.18	.20	.24*a	.14	.19	.19	.20	.55**d	.56**	.85**	.52**d	.82**d	.83**
Eighth	-.10b	-.06b	-.06	-.08b	.15	.17	.10	.16	.79**ac	.64**	.90**	.76**c	.94**c	.88**a
Tenth	.20a	.28**a	.20	.28**a	.26*	.33**	.17	.32**	.59**b	.46**	.85**	.34**d	.79**d	.76**b

*$p < .01$

**$p < .01$

a, b difference $p < .05$

c, d difference $p < .01$

grade both the CLP and the TIPT tape a similar information processing ability to a significant extent.

The next five differences between correlations all involved the eighth grade on the CLP. The near zero correlations of the eighth grade, when sixth and tenth showed significant positive correlations, shows that the CLP did not "work" correctly with the eighth grade group. A brief examination of their tests showed that a high proportion of the eighth graders marked only one item as YES, this being the item that was exactly the same as a YES example. In effect, very few of the eighth grade Ss went beyond the particular instances to a conceptualization of the positive examples as a rule for grouping.

The next seven differences involved GPA correlations. These may be of some interest to the reader and are presented, but with little comment. The generally lower correlations for the tenth grade probably reflect the complete separation of courses that arises in high school.

ANALYSES OF VARIANCE

The HFT score; the IQ score; the GPA of English, mathematics, social studies, and the total of these three; ten dependent measures of the TIPT; and nine dependent measures of the CLP were all analyzed using analysis of variance. A $2 \times 2 \times 3$ factorial design was used with all the analyses, which numbered 25. The factors were high or low HFT score (high score was six or more correct, low was five or below), male or female; and sixth, eighth, or tenth grade. The design and number of Ss in each cell was shown previously in Table 1.

In Table 14 a summary of the F ratios is presented. Table 15 shows the means and standard deviations for each of the factors. Many of the differences between means were significant and these differences generally supported the theoretical implications presented in the introductory chapter. The high-low HFT factor was significant in 14 of the 25 analyses. The sex factor was significant six times, and the grade level factor 14 times.

The Dependent Variables as a Function of HFT Score

It was hypothesized on the basis of theory and research reported in Chapter II that the high scorers on the HFT would show certain characteristics that were different from those of the low scorers. These differences would be particularly noticeable in tasks that required processing of information. More specifically, the high scorers should show their ability to process information by avoiding inclusion errors, while the low scorers should be hampered by inclusion and exclusion errors, especially at high levels of difficulty.

The analyses of the variance of the 25 variables showed that the high scorers were characteristically different from the low scorers. The Ss who showed ability to analyze a pattern, and thus find the hidden figure, had significantly higher IQ scores and averaged significantly higher in their grades in English, social studies, and math than the Ss who might be categorized as global. The difference in IQ between the high and low HFT scorers was approximately 6.5 points, while in total GPA the difference was over 1 point.

Dependent Variables 7 through 16 in Tables 14 and 15 were measures obtained from the TIPT. Variables 7, 8, and 9 were the number of "Yes," "No," and "Can't Tell" items, respectively, that the average S answered correctly. The average high scorer answered more of the "Can't Tell" items correctly than did the average low scorer ($p < .05$). In the case of "Yes" items this difference was statistically significant at the .06 level, high Ss again answering more of these items correctly than low scorers. From the item analyses of earlier sections of this paper and from the means for all Ss on Variables 7, 8, and 9 given in Table 15, the "Can't Tell" items appear to have been the most difficult, and the "No" items easiest. Thus, as the difficulty of the items increased, the difference between high and low Ss also increased. At the highest levels of difficulty, the analytical ability of the high HFT scorers was sufficient to give them a significantly higher score on those difficult items than the low HFT scorers achieved.

Variables 10 and 11 were the number of errors that Ss made on the YES and NO card items, respectively. The absolute number of these errors was higher when the items involved a YES instance than when a NO instance was involved. For both the YES and NO items, the low HFT Ss made significantly ($p < .05$) more errors than the high Ss.

The errors on the YES and NO items were further analyzed as in Variables 12 through 15. Ten of the YES items required a "Yes" response, and the remaining five YES items were "Can't Tell." If the S said "Yes" to an item that was actually "Can't Tell," the S's action could reasonably be interpreted as an inclusion error. By saying "Can't Tell" to an item which was "Yes" the S's error could be reasoned to have been indecision or uncertainty. The remaining errors on the YES items would have

Table 14

Summary of the Analysis of Variance F ratios for the 25 Dependent Variables

Dependent Variable	HFT	Sex	Grade	HFT × Sex	HFT × Grade	Sex × Grade	HFT × Sex × Grade
1. HFT Score	429.44**	2.02	5.51**	2.13	-	-	-
2. IQ	25.61**	7.53**	-	-	-	-	1.28
3. English GPA	17.93**	10.10**	14.61**	-	1.72	-	1.65
4. Social Studies GPA	11.20**	2.22	12.09**	-	-	2.62	-
5. Mathematics GPA	10.94**	-	2.81	1.15	-	-	-
6. Total GPA	18.15**	3.09	11.38**	-	1.14	-	-
7. # Right "Yes" Items	3.82	5.83*	5.65**	-	2.16	-	-
8. # Right "No" Items	2.11	-	2.47	-	-	-	-
9. # Right "CT" Items	5.42*	5.01*	-	1.04	2.30	-	-
10. YES Card Errors	4.27*	6.26*	2.89	-	2.10	-	-
11. NO Card Errors	5.45*	3.35	2.05	-	2.49	-	-
12. "CT" Errors on YES	-	-	4.26*	-	-	-	-
13. "CT" Errors on NO	-	-	2.90	1.85	-	-	1.21
14. "Yes" Errors on YES	1.04	-	4.44*	1.07	-	-	3.32*
15. "No" Errors on NO	-	2.73	1.18	-	-	-	-
16. Total Right, TIPT	7.84**	6.66*	3.63*	-	3.33*	-	-
17. Inclusion Error CLP #1	3.09	-	7.36**	1.42	1.30	-	-
18. Inclusion Error CLP #2	3.48	-	6.53**	-	-	1.40	-
19. Total Inc. Errors CLP	4.86*	-	8.76**	-	-	-	-
20. Exclusion Error CLP #1	-	1.18	-	-	1.48	2.69	-
21. Exclusion Error CLP #2	3.93*	-	7.08**	-	1.34	-	1.10
22. Total Exc. Errors CLP	2.80	-	4.42*	-	-	1.14	-
23. # Right CLP #1	1.67	-	4.88**	2.85	2.84	2.10	1.59
24. # Right CLP #2	7.22**	-	-	-	-	-	-
25. Total Right, CLP	8.11**	-	-	-	1.06	1.98	-

*p < .05

**p < .01

to be interpreted as exclusion errors. By subtraction of "Can't Tell" and "Yes" errors from total errors on YES items, one obtains 3.93, 3.65, and 4.25 exclusion errors for all Ss, high Ss, and low Ss, respectively. The low Ss were not significantly different from the high Ss in the number of "Can't Tell" and "Yes" errors on YES items, so the difference between high and low Ss on the total number of errors on YES items was largely due to the greater number of exclusion errors made by low Ss than by high Ss.

On NO items, a "Can't Tell" error was again an error of indecision, while a "No" error was an exclusion error. No differences existed between high and low Ss on these two types of errors on NO items. Inclusion errors for all Ss and for high and low HFT Ss averaged 2.21, 1.97, and 2.48, respectively on the NO items. In this case the number of inclusion errors accounted for most of the difference between high and low Ss on the NO items.

On total TIPT score, high HFT Ss answered significantly more of the 30 items correctly than did the low HFT Ss (p < .01), thereby supporting the theoretical implications of the HFT as a measure of the ability to articulate information.

The nine dependent variables from the CLP gave further support and clarification of the functional relationship between cognitive style and concept learning. Variables 17-22 were measures of the various types of errors Ss made on the CLP items. Two of these dependent measures yielded significant (p < .05) results. In one case the total number of inclusion errors was greater for Ss who scored low on the HFT than for those Ss who scored high on the HFT. The second significant difference was on the measure of exclusion errors on CLP #2, the more difficult of the two concepts. In this case, the low HFT scorers made more exclusion errors than the high scorers, though on the measure of exclusion errors for both concepts the difference was not significant. These results

Table 15

Means and Standard Deviations by Groups for the Dependent Variables

Group	HFT 1	IQ 2	GPA ENG 3	GPA SS 4	GPA MATH 5	GPA SUM 6	TIPT Correct Item Type Yes 7	TIPT Correct Item Type No 8	TIPT Correct Item Type CT 9	TIPT Errors Card YES 10	TIPT Errors Card NO 11	TIPT Errors CT on YES 12	TIPT Errors CT on NO 13	TIPT Errors Yes on YES 14	TIPT Errors No on NO 15	TIPT TOTAL RIGHT 16	CLF Errors Inclusion #1 17	CLF Errors Inclusion #2 18	CLF Errors Inclusion SUM 19	CLF Errors Exclusion #1 20	CLF Errors Exclusion #2 21	CLF Errors Exclusion SUM 22	CLF Correct #1 23	CLF Correct #2 24	CLF Correct SUM 25
All S's																									
$\bar{X}$	575	10800	240	226	232	698	469	514	429	867	715	307	339	167	155	1412	136	70	206	128	230	358	932	898	1830
sd	260	1103	97	92	94	242	265	221	193							464									303
High																									
$\bar{X}$	765	11101	259	241	250	750	502	536	452	829	678	307	330	157	151	1490	121	54	175	125	214	339	951	930	1881
sd	177	993	96	96	91	244	273	237	198							503									320
Low																									
$\bar{X}$	351	10447	217	208	210	635	431	490	403	911	758	308	350	178	160	1324	155	87	242	132	249	381	911	862	1773
sd	132	1126	94	83	93	225	250	199	183							399									271
Males																									
$\bar{X}$	597	10616	219	216	234	669	436	509	402	907	740	315	326	169	165	1347	141	71	212	135	233	368	919	894	1813
sd	272	1141	102	94	98	257	277	217	191							450									309
Females																									
$\bar{X}$	553	10984	260	236	230	726	502	519	456	827	690	299	352	165	145	1477	131	69	200	122	228	350	945	902	1847
sd	247	1036	87	89	89	224	263	225	191							471									296
Sixth																									
$\bar{X}$	508	10739	218	214	214	646	410	476	446	922	742	342	378	200	152	1332	183	105	288	122	178	300	891	914	1805
sd	234	1159	70	65	66	168	250	227	186							409									296
Eighth																									
$\bar{X}$	565	10789	285	265	249	799	452	511	411	874	747	318	333	161	171	1374	97	66	163	136	252	388	967	882	1849
sd	246	980	103	102	106	282	262	206	191							448									265
Tenth																									
$\bar{X}$	652	10873	218	202	234	654	545	557	429	807	660	260	306	140	145	1531	127	37	164	129	263	392	942	899	1841
sd	281	1163	100	95	102	238	263	223	199							513									342

(All numbers in the body of the table are 100 times the actual value.)

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imply that the analytical Ss have developed an ability to make inclusion decisions more accurately than the global Ss. On the other hand, the global Ss can make exclusion decisions about as well as analytical Ss when the number of irrelevant dimensions is small, but when this number increases the exclusion errors made by global Ss become increasingly frequent.

The Sex Factor

Males and females did not differ significantly in their scores on the HFT. Many previous studies have shown males to be more analytical than females. There is a tendency in this direction in the present data, but apparently the analytical superiority of males over females is not sufficiently developed in the Ss of these age groups. However, the male Ss showed the slight but insignificant superiority over the female Ss despite the fact that on several other measures, namely IQ score, English GPA, and TIPT score, the female Ss were significantly better. Males were about 3.7 points lower than females in IQ. This difference in intelligence levels did not result in a significant difference in overall GPA, however. Only in English were girls achieving higher than boys.

On the TIPT the comparison of males to females was very much a restatement of the comparison of high to low HFT Ss. In fact, except for minor variations, the performance of the group of females looked very much like that of the group of high scorers, while the male Ss closely approximated the means of the group of low HFT Ss. For example, females answered more items correctly than males, the differences lying largely with the "Yes" and "Can't Tell" items, which was similar to the difference between the performance of the high and low HFT Ss on the TIPT. In a manner analogous to the high group, the female Ss showed a superiority over males on YES card items and a nearly significant superiority on NO card items. The similarity of the performance of the group of female Ss to that of the high HFT group suggests that performance on the TIPT is more closely a function of IQ score than of HFT score. The males and females were not significantly different on HFT performance, and yet the comparison of the males to the females on TIPT measures shows a pattern similar to the comparison of low to high HFT scorers. The easy explanation is that the higher IQ score, which was common to both female Ss and high HFT scorers, accounted for the pattern of differences in TIPT performance more adequately than the HFT.

On the CLP, however, no performance differences appeared between the group of males and females, despite the higher IQ of the females. This leaves open the possibility that, in concept learning more so than in information processing, the performance of Ss is determined to a significant extent by the analytical ability of Ss when that analytical ability is measured by tests such as the HFT.

The Developmental Trend in the Analyses of Variance

The groups of sixth, eighth and tenth graders showed no differences in IQ level. They did, however, have significantly different GPA's; the eighth graders were higher than the sixth and tenth graders in English GPA, social studies GPA, and in total GPA. These differences in GPA reflected the different grading practices of each of the schools.

The differences between grade levels on some of the other dependent variables were of considerable theoretical interest, particularly the developmental trend shown by the HFT score, performance on the "Yes" items of the TIPT, and inclusion errors on the CLP. In general, the results pointed to a gradual increase in analytical ability, as shown by the increase in HFT score across grades. This increase in analytical ability was accompanied by a corresponding decrease in the number of inclusion errors. The increasing ability to make inclusion decisions was shown by the significant improvement across grades in the number of "Yes" items on the TIPT that were answered correctly ($p < .01$). It is also shown by the decreasing number of inclusion errors on the CLP as a function of the S's increasing age.

One significant difference that appeared to be inconsistent with the general improvement with increased age was Variable 21. This variable was the number of exclusion errors on CLP #2. The eighth and tenth graders made significantly more of these errors than the sixth graders. An examination of the responses showed that a large number of Ss were systematically misinterpreting the purpose of the CLP. In effect they were not treating the problem as a conceptual task, but rather as one in which they were to find the one test item that was either exactly like the YES items or the one that was the most similar to the YES items. As Grant (1951) has shown, when Ss have the opportunity they will respond perceptually rather than analytically. Ss interpreting the task in this perceptual manner found the exact match to the YES items of CLP #1 in Item 11, and their score was recorded as two exclusion errors since they didn't mark Items 5 and 6 as belonging to the YES set. On CLP #2 no exact match to the YES instances was available in the test items, so the Ss who were misinterpreting would either mark all items "No," or they would pick one item as most like the YES instances. In this case their score would be recorded as either five exclusion errors, or, if they chose one item, as four exclusion errors. There were 68 Ss whose error patterns were indicative of the misinterpretation mentioned above. These 68 Ss were trying to find the one item that fit the YES set and by doing so were inflating the count of the exclusion errors. When the exclusion errors of these Ss were subtracted from the total number of exclusion errors on CLP #2, and the error rate for the remaining Ss recomputed, the new error rates were 1.51, 1.64, and 1.68 for sixth, eighth, and tenth grades, respectively. The rates for the eighth and tenth graders decreased more than the rate for sixth graders because most of the Ss showing the response pattern that was characteristic of misinterpretation were eighth and tenth graders (sixth, eighth, and tenth graders who misinterpreted numbered 9, 29, and 30, respectively). The recomputed error rates for each grade level were not significantly different, implying that except for misinterpretations, there were no differences between grade levels in the number of exclusion errors.

One problem remained; why did greater numbers of eighth and tenth graders interpret the CLP wrongly than of sixth graders. The eighth and tenth graders probably had more background in critically attempting to evaluate tasks, and in becoming "test-wise." In the present instance such evaluation may have steered a certain percentage of Ss away from viewing the YES instances conceptually. Their reasoning might have been that the HFT and the TIPT both required attention to details of the figural instances presented, and did not require conceptualization. The Ss might then have reasoned that CLP #1 and #2 were also perceptual tasks, and that the examiner simply wanted to know if they could find the instance that was the same in all ways as a YES instance.

The presence of misinterpretation suggested that the purpose of the CLP was not clear enough to get an accurate measure of conceptual ability. The number and rate of exclusion errors was spuriously high, and the rate of inclusion errors spuriously low, because of 68 Ss who made no inclusion errors and over 300 exclusion errors on CLP #2. When these rates were adjusted, no significant differences in exclusion errors as a function of grade level were found. The average rate of inclusion errors on CLP #2 for each grade level when the 68 Ss were excluded was altered from 1.05, .66, and .37 to 1.16, 1.02, and .57, respectively, the latter set showing significant differences ($p < .05$) and interpretable as previously stated. A check of the 68 Ss revealed they were split 36-32 between the high and low HFT groups, and 34-34 between male and female Ss. Thus, these group averages remained stable relative to each other.

Two interactions were significant. Variable 14 showed a three way interaction significant at the .05 level and largely uninterpretable. The other involved a HFT × Grade interaction on total TIPT score. The high scorers performed better on the TIPT as their grade level increased, the mean scores being 13.6, 14.0, and 16.7 for grades six, eight, and ten, respectively. The means of the low scorers, on the other hand, remained stationary regardless of grade level, the mean number correct being 13.1, 13.4, and 13.2. This interaction supported the previous explanation of the relationship between the TIPT and the HFT. As grade increases, those Ss who are high in analytical ability can apply these abilities in information processing tasks more and more efficiently.

OTHER ANALYSES

The number of males and females at each grade level who scored over six correct on the HFT is given in Table 16. When these numbers were compared to the numbers that would be expected if the 90 Ss were distributed proportionately, a chi-square value of 7.96, which was significant ($p < .02$), resulted. This implies that proportionately more males scored high on the HFT than females. The chi-square value for the observed number compared to the number expected if there were no interaction was 2.28. This value was not significant, indicating that the trend for the proportion of high males to increase with increasing grade was not statistically different from a chance occurrence.

Table 16

Observed Numbers of Ss Scoring over Six Items Correct on the HFT by Grade and Sex, Compared to (A) the Numbers Expected Proportionately and (B) the Numbers Expected Assuming No Grade by Sex Interaction

Grade	Males			Females		
	Observed	Expected A	Expected B	Observed	Expected A	Expected B
Six	11	15	12.7	11	16	9.3
Eight	15	13	16.8	14	16	12.2
Ten	26	17	22.5	13	13	16.5

(A) $\chi^2 = 7.96$ df = 2 $p < .02$
(B) $\chi^2 = 2.28$ df = 2 not significant

V

CONCLUSIONS AND SUMMARY

CONCLUSIONS

From the results of the experiment, the following conclusions seem warranted:

1. There is a significant increase in analytical ability as Ss increase in age from 12 to 16 years old. Males and females do not differ in average analytical ability, but proportionately more males than females are high analytical.

2. The items of the Hidden Figures Test vary significantly in difficulty. The A items are easier than the D and E items while B and C items are intermediate. A guessing bias exists; options C and D are chosen more often than expected. As the relevant lines or relevant area in the figure increases, the hidden figure is easier to locate. As the irrelevant lines, figures, area, or intersections increase, finding the hidden figure is more difficult. The ratios of relevant to irrelevant information correlate well with item difficulty. As the value of these ratios increase, the figure is easier to locate. Combining various of the measures of relevant information and the ratios provides the best predictor of item difficulty.

3. Young analytical Ss are more sensitive to the amounts of relevant and irrelevant information than are the global Ss. As the analytical Ss grow more mature, their sensitivity to absolute and relative amounts of each type of information decreases. With age, the Ss develop powers of analysis that are independent of the information load. Males and females do not react differentially to any measure of information.

4. Analytical Ss are significantly superior to global Ss in the ability to process information and attain concepts.

5. The analytical Ss show higher school achievement in English, social studies, and mathematics than do the global Ss. The analytical Ss are generally more intelligent. Information processing and concept learning each correlate significantly with intelligence and to a lesser extent with achievement.

6. English, social studies, and mathematics are equally useful in predicting success in analytical ability, information processing, and concept learning.

7. Global Ss show more errors of inclusion, exclusion, and indecision in information processing than do analytical Ss. In concept learning, global Ss also show more overall inclusion errors, and when concepts are difficult, more exclusion errors than the analytical Ss. Female Ss make fewer errors of inclusion, exclusion, and indecision in information processing than male Ss. As grade level increases, the Ss show an increasing ability to make fewer inclusion errors in both information processing and concept learning.

8. Females are slightly better than males in processing information, but no differences appear in concept learning. With increasing grade level the analytical Ss increase in the ability to process information. Ability in concept learning increases with age.

9. The Hidden Figures Test shows an adequate level of internal consistency and all the items contribute to the reliability of the instrument. The items are difficult for sixth through tenth graders, but the test discriminates satisfactorily among individuals. The test of information processing shows good internal consistency though some of the items contribute little to the reliability of the instrument. The YES items are more difficult and more reliable then the NO items. The several dependent measures that the test provides make it a good research tool. The concept learning problems are also very reliable. The "Yes" response items are generally much more difficult than the "No" response items. A change of instructions is needed so that all Ss understand that it is a conceptual task rather than a strictly perceptual task. An analysis of types of errors is very useful with the concept learning problems.

SUMMARY

The Problem

The Hidden Figures Test (HFT) was used to measure the level of field articulation (LFA) of adolescents. Performance on tests of information processing (TIPT) and concept learning (CLP) provided data on errors of inclusion, exclusion, and indecision. Intelligence, achievement, TIPT and CLP scores, and errors were analyzed as a function of LFA. Sex differences and developmental trends were noted. The HFT was analyzed to find whether item difficulty correlated with amounts of relevant and irrelevant information in the item. Psychometric data on all three tests were obtained.

Related Literature

Experiments showed that (a) tests of LFA are stable and reliable and show large intraindividual consistencies and interindividual differences;(b) LFA is probably the ability to actively separate relevant from irrelevant information; (c) males are sometimes higher than females in LFA; often no differences appear;(d) analytical ability clearly increases during adolescence;(e) a high LFA correlates positively with IQ tests or with certain parts of IQ tests; (f) Strength of Closure is associated with LFA and also with conceptual behavior; (g) LFA correlates positively with conceptual behavior; and (h) concept learning is not a unitary factor; several kinds of information processing are involved.

Methodology

The HFT, TIPT, and CLP were given to 256 boys and girls in Grades 6, 8, and 10. Group testing was used, and Ss were paced on the test items and were to answer every item. Item analyses, correlational studies, and analyses of variance were done.

Results and Conclusions

The Hoyt reliabilities of the HFT, TIPT, and CLP were .50, .69, and .65, respectively. In the HFT, figure A was easier to locate than figures D and E, a guessing bias existed for figures C and D, and the percent of Ss answering an item correctly ranged from 27 to 50. Of 15 measures of the HFT items (a) two measures of the amounts of relevant information correlated .33 and .47 with item difficulty; (b) five measures of irrelevant information correlated -.09, -.34, .01, .10, -.29; (c) three ratios of relevant to irrelevant correlated .31, .43, .32; and (d) a combination of measures in a and c correlated .50. The performance of sixth grade high HFT scorers was more sensitive to the measures in a, b, c, and d than were the high eighth graders who in turn were more sensitive to these measures than high tenth graders. The grade difference was interpreted as a gradual decrease in the dependence of information processing upon absolute and relative amounts of relevant and irrelevant information. Males and females reacted similarly to a, b, c, and d, but the performance of low HFT Ss was different from high Ss in that it correlated only with a measure of relevant area.

IQ correlated with HFT, TIPT, and CLP score .38, .30, and .25, respectively; GPA correlated .26, .20, and .15, respectively. HFT correlated .24 with TIPT and .15 with CLP. As grade increased, the correlation between HFT and TIPT also increased, which showed that information processing ability becomes an increasing part of LFA.

A $2 \times 2 \times 3$ analysis of variance with the factors high or low HFT, sex, and grade level showed that the high HFT Ss had higher IQ scores and GPA, and were better on the TIPT and CLP than the low HFT Ss ($p < .01$). Furthermore, they made fewer inclusion, exclusion, and indecision errors on the TIPT and CLP than the low HFT Ss ($p < .05$). These differences between high and low Ss were more pronounced as the difficulty level of items increased. The females had higher IQ scores than the males ($p < .01$) and made fewer inclusion and indecision errors on the TIPT ($p < .05$). With increasing age, the Ss became more analytical ($p < .01$) and tended to make fewer inclusion errors ($p < .05$).

It was concluded that the HFT does measure LFA in adolescents, and that significant differences between analytical and global Ss exist in intelligence, achievement, and in information processing and concept learning abilities. However, certain limitations of the present study need to be recognized and caution must be applied to the generality of the results because of these limitations. With hindsight several procedural changes seem appropriate. The method of obtaining the GPA should be changed from self-report to looking at the school records so that there would be no false reports. Furthermore, the pacing of the items and the forced response may have affected performance on the three tests in a way that has not been experimentally determined. The HFT and the TIPT were very difficult, but most of the items in the CLP were very easy. How this differential difficulty affected the various constructs being

measured and the relationships among these constructs is not known. The reliabilities of the three tests, while reasonable for determining group characteristics, were not high enough to merit the use of the tests as diagnostic instruments. There was also the problem of the task of the CLP being misinterpreted by some of the _S_s. The instructions for the CLP need to be restated so that _S_s understand that they are to view the task conceptually. The instructions for the TIPT also need changing to reduce the time and amount of material.

Furthermore, it must be remembered that several of the constructs have precise operational referents and that it was the relationships between these precise meanings that were analyzed. Terms such as level of field articulation, analytical, concept learning, information processing, intelligence, achievement, and inclusion errors are examples of such constructs which in this paper have been rather narrowly defined. Caution must be used if these constructs and the results relating the constructs are interpreted more broadly than the operational referents permit.

APPENDIX A: TESTS

Includes Hidden Figures Test, Tagatz Information Processing Test, and The Concept Learning Problems.

Pages 37-44

INFORMATION PROCESSING

You are going to be shown sets of three cards. These are the six properties making up each card: The first two properties deal with the border. That is, all cards have one or two borders which are solid or broken. The last four properties deal with the figures on the cards. The figures may be textured or open, small or large, circular or square, and there may be one or two.

Using these six properties, many different cards can be made. As an example, consider the cards below. The first card may be described as one solid border with one large textured square figure.

(Henceforth, cards will not be drawn in this appendix except for one example of a problem. Instead, all cards will be represented by a symbol such as 1S1sTC or 2B2LOQ, where each of the six letters or digits equals one of the values of the six dimensions. The two cards above would be represented by 1S1LTQ and 2S1LOC.)

The second card has two solid borders with one large open circular figure. The two cards above are different in border number and figure texture and figure shape. They are the same in the other ways. Consider the following card and describe it in terms of the six properties.

(2B2sTQ)

You should have described this card as having two broken borders with two small textured square figures.

There are a number of ways certain cards may be grouped so that the group has one or more of the same properties. As an example, consider the three cards on the next page:

(1S2LTQ) (1B2sTQ) (2S2sTC)

These three cards can be grouped together on the basis that all three have two textured figures. They are different in border number, border type, figure shape, and figure size.

Similarly the following figures can be grouped together on the basis that all three have two borders with two square figures.

(2S2sOQ) (2B2sTQ) (2S2LTQ)

You determine the rule for grouping the following cards.

(1S1sTQ) (1S2sTC) (2B1sTQ)

You should have decided that the rule for grouping these cards was small textured figures. Which of the following cards fit the rule, one border with textured square figures?

(1S1LTQ) (1B2sTQ) (2S2LTQ)

You should have identified the first two cards as belonging to the group, one border with textured square figures, and the last card as not belonging to the group. In terms of the rule, one border with textured square figures, the first two cards above are YES cards and the last is a NO card.

In the next example you will see three cards, one labeled YES, one labeled FOCUS CARD, and the lower one with a question mark (?). The FOCUS CARD is an example of a rule just like the

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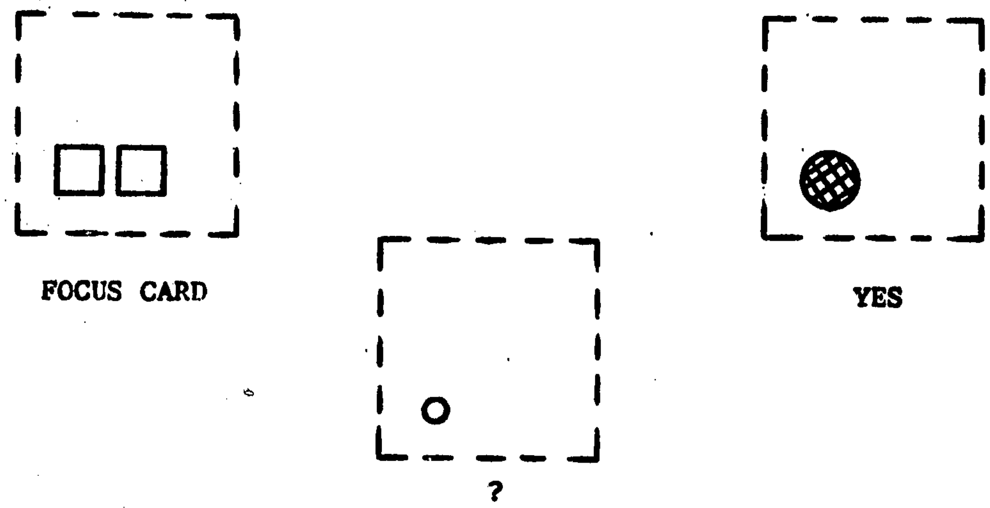
YES card. Note that the card in the upper right hand corner is a YES card, which tells you that it is an example of the same rule as the FOCUS CARD. Take a moment and decide if the "?" card in the example below is a YES card, a NO card, or if you can't tell which.



YES_____

NO_____

Can't Tell_____

You should have decided that you can't tell, because you have no information about figure size. The rule might have been one broken border with large figures, or simply one broken border.

Before leaving this example, pay particular attention to the difference between small and large figures so that you can distinguish between them.

Consider another example:

(FOCUS CARD 2S1LTQ) (YES CARD 2S2sOQ) (? CARD 2S1sTQ)

The FOCUS CARD has two solid borders with one large textured square figure. The YES card tells you that size, texture, and number of figures are not part of the rule. From this information you should be able to determine that the third card must also be a YES card.

Consider an example in which the second card is a NO card:

(FOCUS CARD 2B1LTQ) (NO CARD 2B2LTQ) (? CARD 2B2LTC)

In this example the NO card differs from the FOCUS CARD only in the number of figures. The rule for grouping the YES cards must include <u>one</u> figure. The bottom card has two figures. Therefore, it can't belong to the group specified by the rule, and so the "?" card is a NO card.

Consider another example:

(FOCUS CARD 2B1LTQ) (NO CARD 2B2LOQ) (? CARD 2B2LTQ)

In this example the FOCUS CARD and NO card do not give you enough information to decide if the third card belongs to the rule because you cannot tell whether number of figures, or figure texture is part of the rule. The right answer is that you Can't Tell.

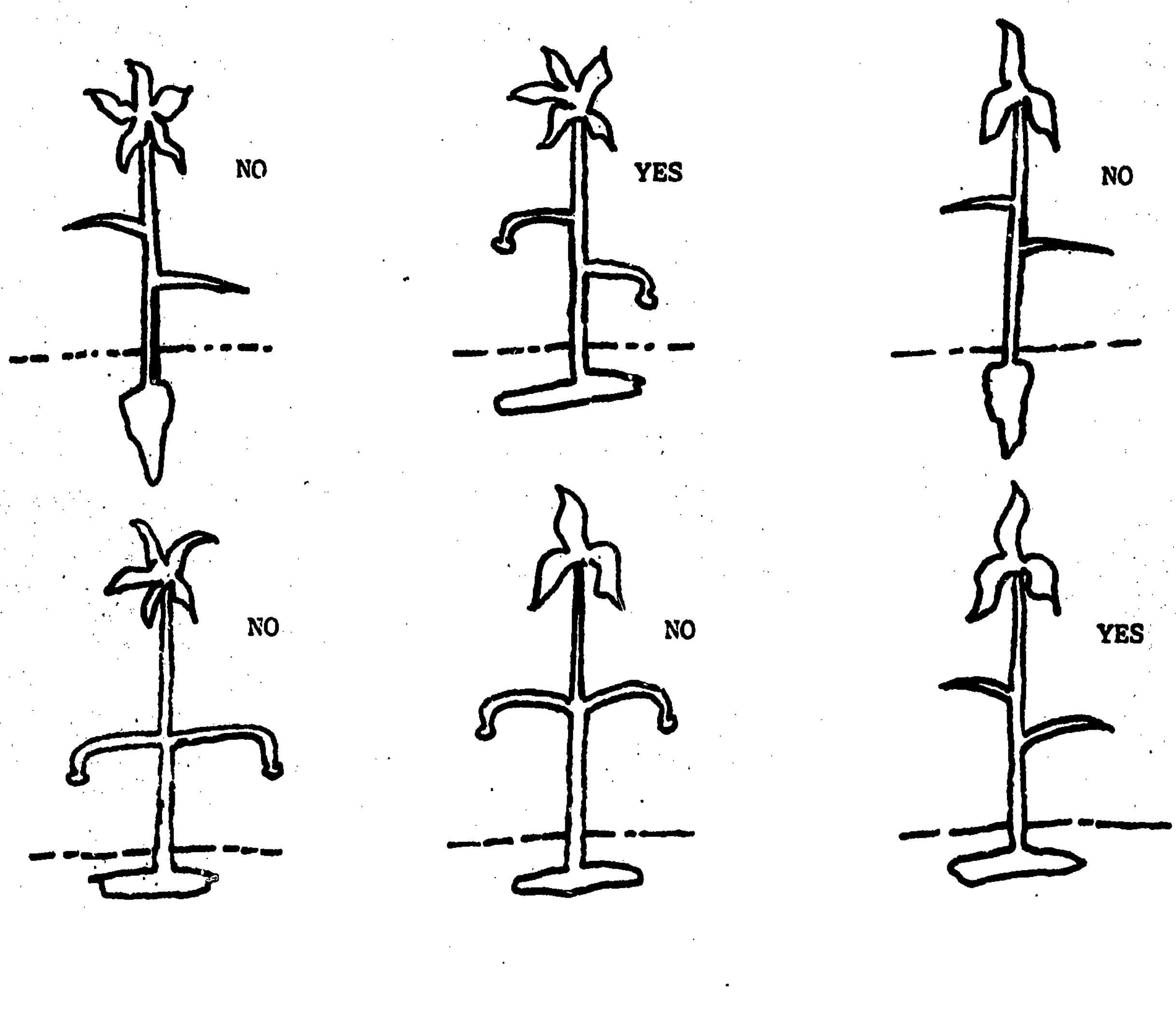
Beginning on the next page there are 30 such sets of three cards. In each problem you must mark whether the third card is YES, NO, or Can't Tell. You will have 20 seconds for each problem; the instructor will tell you when and how to proceed.

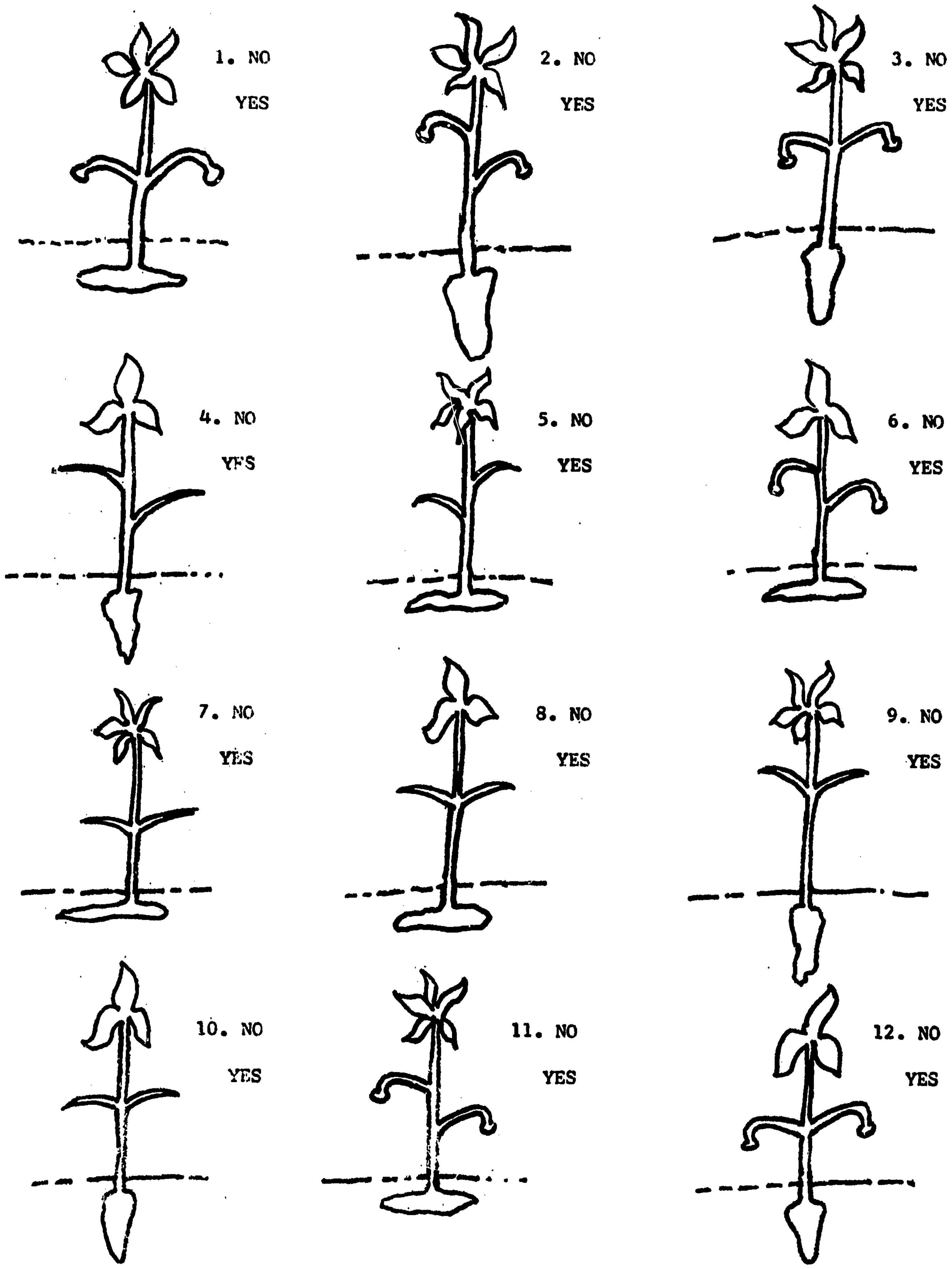
(The 30 TIPT Items)

FOCUS CARD	YES CARD	NO CARD	? CARD
1. 1B2LOQ		1B2sTQ	2S2sTQ
2. 2S1sTC	1S2sTC		1S1sTC
3. 2S1sTC		2S1LTQ	2S2LOC
4. 2B2sOQ	1S1sOQ		1B1sOQ
5. 2S1LOQ		2S1sTC	2S2sTQ
6. 2S2sOQ	1S1sTQ		2S1sTQ
7. 2S1sTC		2B1sTC	2B1LOC
8. 1B1LOC	2S1sTC		1B1sTC
9. 1B2LOQ		2B1LOQ	2S2LOC
10. 2B1sTC	1B1LTC		1B1sOC
11. 2S2LOQ		1S2LOQ	1S1sOC
12. 1B2sTQ	2S2LOC		1B2LOC
13. 2S2LOQ	2S2sOC		2B2sOC
14. 2B1LOC	2S1sOQ		1B1sOQ
15. 2B2LTC	2B2sOC		2B1sOC
16. 1S2LOC	2B1sTQ		1S2sTC
17. 2S2sTQ	1S2sTQ		1S2LOQ
18. 1B2LTQ	2S2sOC		2B2LTQ
19. 1B2LTQ		1B2sTQ	1B2sOC
20. 2S2LTQ	1B2sOC		2S2sTC
21. 2S2LTQ		2S2sTC	2S2sOC
22. 1B1sTQ		2B2LOC	2S2LOC
23. 1S2LTQ		2S2LTQ	2B1LTQ
24. 1S1LOC		1B1LOQ	2B1LOC
25. 1S2sTQ		2B2sTQ	2B1sTQ
26. 2S2LTC		2B1sTC	1B1sTC
27. 2S1LOQ	2S1LTC		2S1LTQ
28. 2S1LTC		1B2sTQ	2S2sTQ
29. 1B2sOQ	1B2LOC		1B2LOQ
30. 1S2sOQ		1B1LTQ	2S1sTQ

(The Concept Learning Problems)
Mr. X

Mr. X was stranded on a very strange island. On this island were unusual plants and animals. The plants were strange because some of them had five petals, others had three petals; some had pointed leaves, others had rounded leaves; some had their leaves together, others had their leaves staggered; and some had flat roots while others had deep roots. Mr. X had to eat so he ate various plants. Some of the plants made him sick, but others were very nutritious. Soon he could tell which plants were good to eat and which would make him sick just by looking at the plants. Below are six plants that were common on the island. The ones that are good to eat are marked YES, and the ones that would make Mr. X sick are marked NO. Study these plants for awhile so that you can recognize the ones that are good to eat from the ones that are not good to eat.

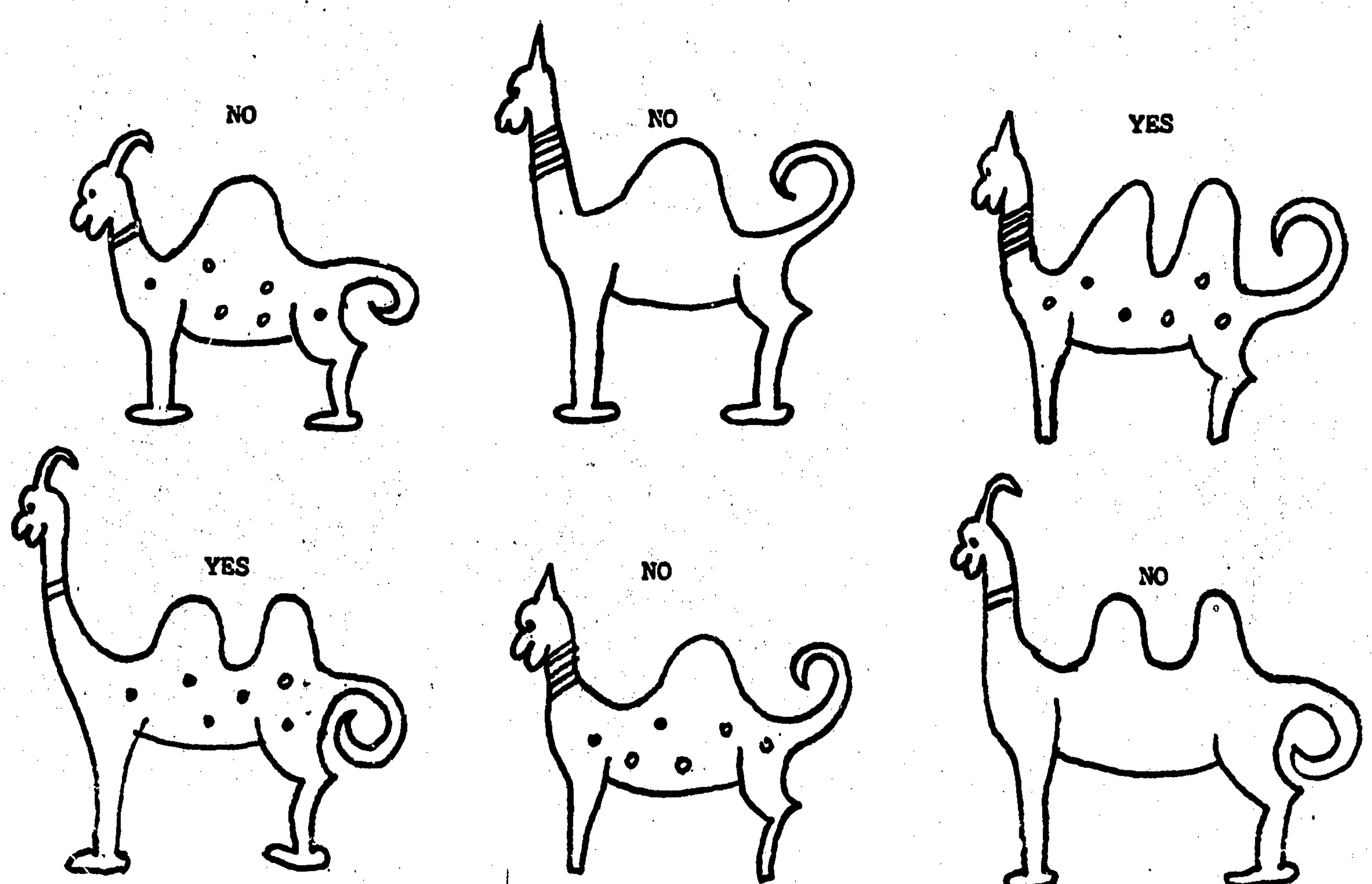



1. NO
YES
2. NO
YES
3. NO
YES
4. NO
YES
5. NO
YES
6. NO
YES
7. NO
YES
8. NO
YES
9. NO
YES
10. NO
YES
11. NO
YES
12. NO
YES

Mr. X

Mr. X was stranded on a very strange island. On this island were unusual plants and animals. The animals were especially strange, for some had long necks and others short necks; some had tails that curled up, others tails that curled down; some had straight ears, others floppy ears; some had one hump, others two humps; some had spots, others had no spots; some had five rings around their necks, others had two rings; and some had big feet while others had tiny feet.

At first Mr. X was bitten by several of the animals, but soon he was able to tell which ones would bite just by looking at the animals. Below are six animals that were common on the island. The ones that would bite are marked YES, and the ones that would never bite are marked NO. Study these animals for awhile so that you can recognize the ones that bite from the ones that don't bite.



APPENDIX B: SUPPLEMENTARY TABLES

Table I

Scheffe Post Hoc Comparison of Items from the Hidden Figures Test (n = 16, N = 256)

Item Number		16	1	8	11	12	2	3	6	9	4	14	10	5	15	7	13
Answer		C	A	A	C	A	B	E	D	B	D	E	D	B	C	E	E
Score		128	120	109	108	107	103	95	85	85	84	82	82	74	72	70	69
Item	Score																
16	128	0	8	19	20	21	25	33	43	43	44	46	46	54	56	58	59
1	120		0	11	12	13	17	25	35	35	36	38	38	46	48	50	51
8	109			0	1	2	6	14	24	24	25	27	27	35	37	39	40
11	108				0	1	5	13	23	23	24	26	26	34	36	38	39
12	107					0	4	12	22	22	23	25	25	33	35	37	38
2	103						0	8	18	18	19	21	21	29	31	33	34
3	95							0	10	10	11	13	13	21	23	25	26
6	85								0	0	1	3	3	11	13	15	16
9	85									0	1	3	3	11	13	15	16
4	84										0	2	2	10	12	14	15
14	82											0	0	8	10	12	13
10	82												0	8	10	12	13
5	74													0	2	4	5
15	72														0	2	3
7	70															0	1
13	69																0

All differences greater than 57 are significant at the .01 level, differences greater than 52 at the .05 level, and 49 at the .10 level.

Table II

Scheffé Post Hoc Comparison of Items from the Tagatz Information Processing Test (n = 30, N = 256)

Item Number		3	27	29	30	22	2	19	12	21	25	7	11	9	4	1	24	26	23	5	6	28	20	8	14	18	10	17	13	15	16
Answer		CT	Y	Y	CT	N	Y	N	Y	N	N	N	N	CT	Y	N	CT	N	N	N	Y	CT	Y	Y	CT	Y	CT	CT	CT	CT	Y
Item	Score																														
3	165	0	7	9	15	17	19	24	29	29	30	30	31	32	39	40	40	41	45	45	50	51	52	61	64	77	82	83	86	100	104
27	158		0	2	8	10	12	17	22	22	23	23	24	25	32	33	33	34	38	38	43	44	45	54	57	70	75	76	79	93	97
29	156			0	6	8	10	15	20	20	21	21	22	23	30	31	31	32	36	36	41	42	43	52	55	68	73	74	77	91	95
30	150				0	2	4	9	14	14	15	15	16	17	24	25	25	26	30	30	35	36	37	46	49	62	67	68	71	85	89
22	148					0	2	7	12	12	13	13	14	15	22	23	23	24	28	28	33	34	35	44	47	60	65	66	69	83	87
2	146						0	5	10	10	11	11	12	13	20	21	21	22	26	26	31	32	33	42	45	58	63	64	67	81	85
19	141							0	5	5	6	6	7	8	15	16	16	17	21	21	26	27	28	37	40	53	58	59	62	76	80
12	136								0	0	1	1	2	3	10	11	11	12	16	16	21	22	23	32	35	48	53	54	57	71	75
21	136									0	1	1	2	3	10	11	11	12	16	16	21	22	23	32	35	48	53	54	57	71	75
25	135										0	0	1	2	9	10	10	11	15	15	20	21	22	31	34	47	52	53	56	70	74
7	135											0	1	2	9	10	10	11	15	15	20	21	22	31	34	47	52	53	56	70	74
11	134												0	1	8	9	9	10	14	14	19	20	21	30	33	46	51	52	55	69	73
9	133													0	7	8	8	9	13	13	18	19	20	29	32	45	50	51	54	68	72
4	126														0	1	1	2	6	6	11	12	13	22	25	38	43	44	47	61	65
1	125															0	0	1	5	5	10	11	12	21	24	37	42	43	46	60	64
24	125																0	1	5	5	10	11	12	21	24	37	42	43	46	60	64
26	124																	0	4	4	9	10	11	20	23	36	41	42	45	59	63
23	120																		0	0	5	6	7	16	19	32	37	38	41	55	59
5	120																			0	5	6	7	16	19	32	37	38	41	55	59
6	115																				0	1	2	11	14	27	32	33	36	50	54
28	114																					0	1	10	13	26	31	32	35	49	53
20	113																						0	9	12	25	30	31	34	48	52
8	104																							0	3	16	21	22	25	39	43
14	101																								0	13	18	19	22	36	40
18	88																									0	5	6	9	23	27
10	83																										0	1	4	18	22
17	82																											0	3	17	21
13	79																												0	14	18
15	65																													0	4

Differences greater than 75, $p < .01$
Differences greater than 69, $p < .05$
Differences greater than 66, $p < .10$

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Table III

Scheffé Post Hoc Comparison of Items from the Two Concept Learning Problems (n = 24, N = 256)

Item Number		9	3	20	12	13	2	16	4	22	10	24	11	18	21	7	17	1	8	15	19	14	23	5	6
Answer		N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	Y	N	N	Y	Y	Y	Y	Y	Y
Score		248	243	239	235	235	234	231	231	229	228	227	226	226	222	208	181	167	153	143	126	120	116	106	105
Item	Score																								
9	248	0	5	9	13	13	14	17	17	19	20	21	22	22	26	40	67	81	95	105	122	128	132	142	143
3	243		0	4	8	8	9	12	12	14	15	16	17	17	21	35	62	76	90	100	117	123	127	137	138
20	239			0	4	4	5	8	8	10	11	12	13	13	17	31	58	72	86	96	113	119	123	133	134
12	235				0	0	1	4	4	6	7	8	9	9	13	27	54	68	82	92	109	115	119	129	130
13	235					0	1	4	4	6	7	8	9	9	13	27	54	68	82	92	109	115	119	129	130
2	234						0	3	3	5	6	7	8	8	12	26	53	67	81	91	108	114	118	128	129
16	231							0	0	2	3	4	5	5	9	23	50	64	78	88	105	111	115	125	126
4	231								0	2	3	4	5	5	9	23	50	64	78	88	105	111	115	125	126
22	229									0	1	2	3	3	7	21	48	62	76	86	103	109	113	123	124
10	228										0	1	2	2	6	20	47	61	75	85	102	108	112	122	123
24	227											0	1	1	5	19	46	60	74	84	101	107	111	121	122
11	226												0	0	4	18	45	59	73	83	100	106	110	120	121
18	226													0	4	18	45	59	73	83	100	106	110	120	121
21	222														0	14	41	55	69	79	96	102	106	116	117
7	208															0	27	41	55	65	82	88	92	102	103
17	181																0	14	28	38	55	61	65	75	76
1	167																	0	14	24	41	47	51	61	62
8	153																		0	10	27	33	37	47	48
15	143																			0	17	23	27	37	38
19	126																				0	6	10	20	21
14	120																					0	4	14	15
23	116																						0	10	11
5	106																							0	1
6	105																								0

All differences greater than 53 are significant at the .01 level, 49 at .05, and 46 at .10.

Table VI

The Dependent and Independent Measures of the Items in the Hidden Figures Test (Part I)

	Item Number and Answer															
Measure	1 A	2 B	3 E	4 D	5 B	6 D	7 E	8 A	9 B	10 D	11 C	12 A	13 E	14 E	15 C	16 C
1. Number of sixth grade Ss who answered correctly	40	36	26	20	16	26	24	38	22	27	25	27	29	27	29	37
2. Eighth Grade Ss	38	26	32	23	26	27	24	35	32	22	37	38	18	20	21	43
3. Tenth Grade Ss	42	41	37	41	32	32	22	36	31	33	46	41	22	35	22	48
4. Males	54	53	53	46	44	48	37	55	41	41	52	60	33	46	40	63
5. Females	66	50	42	38	30	37	33	54	44	41	56	46	36	36	32	65
6. High HFT Scorers	82	73	70	66	55	58	60	82	57	54	80	78	52	53	48	88
7. Low HFT Scorers	38	30	25	18	19	27	10	27	28	28	28	28	17	29	24	40
8. All Ss	120	103	95	84	74	85	70	109	85	82	108	106	69	82	72	128
9. Item Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
10. Lines in the Figure	6	4	6	4	4	4	6	6	4	4	7	6	6	6	7	7
11. Closed Figures	12	21	24	22	24	30	16	17	27	31	36	24	26	20	23	26
12. Lines in the Pattern	18	17	19	23	26	22	14	18	20	27	29	21	21	23	26	15
13. Ratio 10/11	.50	.19	.25	.18	.17	.13	.38	.35	.15	.13	.19	.25	.23	.30	.30	.27
14. Ratio 10/12	.33	.24	.32	.17	.15	.18	.43	.33	.20	.15	.24	.29	.29	.26	.27	.47
15. Distance	10	9	8	10	6	2	8	4	8	6	4	9	8	11	8	2
16. Lines of Symmetry	4	0	0	1	4	1	0	0	1	0	1	1	1	1	1	2
17. Area of the Figure	7	5	5	7	5	7	5	7	5	7	7	7	5	5	7	7
18. Area of the Pattern	32	40	24	32	32	32	24	24	40	32	36	50	40	32	40	32
19. Ratio 17/18	.22	.12	.21	.22	.16	.22	.21	.29	.12	.22	.19	.14	.12	.16	.18	.22
20. Partitions of Figure	2	3	5	4	3	7	4	4	3	8	7	3	4	3	4	7
21. Intersections	17	24	24	27	25	29	19	19	26	29	32	24	28	25	33	27
22. Variance	.20	.34	.88	1.45	.53	.67	.49	.45	1.27	1.23	1.64	1.06	.25	.73	1.57	.78
23. Combination	170	100	133	112	93	108	157	162	92	105	132	133	119	127	145	166

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GPO 808-037-2